STORM 38 - NOV 19-22, 1921
ENTIRE STORM
45 28'N 121 52'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.56	4.06	4.84	5.98	8.30	9.71	11.23	12.15	12.57	12.88	13.47	13.75	14.18
10	1.54	4.01	4.84	5.98	8.30	9.71	11.23	12.13	12.44	12.79	13.23	13.70	14.18
50	1.44	3.76	4.71	5.86	8.11	9.53	11.02	11.93	12.25	12.62	13.07	13.55	14.03
100	1.28	3.33	4.29	5.62	7.72	9.15	10.59	11.50	11.84	12.27	12.72	13.24	13.71
200	1.28	3.33	3.98	5.26	7.31	8.53	9.89	10.79	11.15	11.67	12.12	12.69	13.14
500	1.24	3.21	3.70	5.07	7.09	8.13	9.23	10.15	10.52	11.02	11.49	11.91	12.39
1000	1.14	2.96	3.50	4.86	6.83	7.87	8.89	9.52	9.76	10.24	10.68	11.21	11.55
2000	0.95	2.50	3.26	4.50	6.35	7.31	8.30	8.90	9.11	9.58	9.98	10.44	10.81
5000	0.75	2.07	3.02	4.03	5.64	6.62	7.64	8.29	8.57	8.99	9.34	9.84	10.19
10000	0.60	1.74	2.72	3.60	4.96	5.80	6.76	7.36	7.63	7.95	8.34	8.77	9.10
20000	0.45	1.41	2.35	3.17	4.14	4.81	5.70	6.23	6.44	6.70	7.25	7.52	7.86
50000	0.28	0.95	1.59	2.13	2.69	3.11	3.69	4.06	4.29	4.78	5.25	5.43	5.66
73110	0.22	0.76	1.26	1.69	2.13	2.47	2.94	3.26	3.49	3.87	4.28	4.45	4.66

STORM 40 - DEC 9-12, 1921
WASHINGTON CASCADES CENTER
48 01'N 121 32'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
2	1.30	3.58	5.35	6.79	8.61	10.66	11.82	12.57	12.57	13.92	16.14	17.67	19.31
10	1.30	3.58	5.35	6.79	8.59	10.66	11.82	12.57	12.57	13.92	16.14	17.67	19.31
50	1.27	3.48	5.26	6.68	8.34	10.36	11.49	12.24	12.24	13.53	15.69	17.17	18.76
100	1.23	3.37	5.12	6.50	8.16	10.14	11.24	11.96	11.96	13.19	15.31	16.76	18.29
200	1.16	3.19	4.89	6.22	7.89	9.80	10.87	11.56	11.56	12.64	14.72	16.09	17.52
500	1.01	2.78	4.60	5.89	7.47	9.28	10.28	10.96	10.96	11.58	13.64	14.87	16.05
1000	0.90	2.54	4.38	5.64	7.21	8.95	9.93	10.60	10.60	10.90	12.94	14.06	14.98
2000	0.78	2.36	4.16	5.37	6.91	8.57	9.56	10.20	10.20	10.36	12.29	13.27	13.93
5000	0.63	2.06	3.59	4.62	5.91	7.39	8.33	8.92	8.92	8.95	10.63	11.43	11.90
8662	0.49	1.72	3.02	3.94	4.96	6.24	7.05	7.57	7.57	7.61	8.96	9.62	10.02

STORM 40 - DEC 9-12, 1921
COASTAL WASHINGTON CENTER
47 40'N 123 26'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.05	3.25	4.96	6.55	7.68	9.32	10.77	11.61	11.61	11.61	12.48	12.84	13.14
10	1.05	3.06	4.96	6.55	7.39	9.32	10.77	11.61	11.61	11.61	12.48	12.84	13.14
50	1.05	2.94	4.83	6.39	7.26	9.32	10.77	11.61	11.61	11.61	12.48	12.84	13.14
100	1.05	2.87	4.73	6.26	7.10	9.08	10.57	11.42	11.43	11.43	12.31	12.66	12.96
200	0.96	2.72	4.54	6.01	6.91	8.79	10.32	11.19	11.22	11.22	12.11	12.45	12.75
500	0.83	2.37	4.08	5.42	6.42	8.22	9.75	10.67	10.70	10.72	11.74	12.09	12.38
1000	0.73	2.09	3.59	4.82	5.88	7.67	9.13	10.12	10.14	10.18	11.37	11.75	12.04
2000	0.63	1.91	3.30	4.49	5.39	7.15	8.54	9.56	9.59	9.66	10.98	11.38	11.66
5000	0.47	1.58	2.78	3.92	4.87	6.35	7.54	8.46	8.50	8.57	9.68	10.05	10.29
9243	0.30	1.23	2.31	3.42	4.49	5.65	6.58	7.45	7.56	7.60	8.45	8.76	8.94

STORM 40 - DEC 9-12, 1921
ENTIRE STORM
48 01'N 121 32'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.30	3.58	5.35	6.79	8.61	10.66	11.82	12.57	12.57	13.92	16.14	17.67	19.31
10	1.30	3.58	5.35	6.79	8.58	10.66	11.82	12.57	12.57	13.92	16.14	17.67	19.31
50	1.27	3.48	5.26	6.68	8.34	10.36	11.49	12.24	12.24	13.53	15.69	17.17	18.76
100	1.23	3.37	5.12	6.50	8.16	10.14	11.24	11.96	11.96	13.19	15.31	16.76	18.29
200	1.16	3.19	4.89	6.22	7.89	9.80	10.87	11.56	11.56	12.64	14.72	16.09	17.52
500	1.01	2.77	4.60	5.89	7.47	9.28	10.28	10.96	10.96	11.58	13.64	14.87	16.05
1000	0.90	2.54	4.38	5.64	7.21	8.95	9.92	10.60	10.60	10.90	12.94	14.06	14.98
2000	0.78	2.36	4.16	5.37	6.91	8.57	9.56	10.20	10.20	10.36	12.29	13.27	13.93
5000	0.63	2.06	3.59	4.62	5.91	7.39	8.33	8.92	8.92	8.95	10.63	11.43	11.90
10000	0.46	1.66	2.93	3.85	4.86	6.09	6.90	7.45	7.50	7.53	8.80	9.41	9.80
20000	0.31	1.36	2.50	3.43	4.35	5.39	6.19	6.89	6.94	6.95	7.98	8.44	8.73
27253	0.25	1.22	2.28	3.17	3.99	4.92	5.66	6.35	6.41	6.42	7.30	7.68	7.93

STORM 59 - MAR 30 - APR 1, 1931
ENTIRE STORM
46 00'N 118 00'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60
1	0.84	2.06	3.14	3.50	4.79	5.49	5.79	5.87	5.96	6.00	6.00
10	0.84	2.06	3.14	3.50	4.79	5.49	5.79	5.87	5.96	6.00	6.00
50	0.83	1.97	3.12	3.39	4.66	5.35	5.64	5.72	5.81	5.85	5.85
100	0.79	1.93	3.00	3.34	4.60	5.28	5.58	5.65	5.74	5.78	5.78
200	0.75	1.82	2.88	3.17	4.39	5.04	5.32	5.39	5.48	5.52	5.52
500	0.70	1.59	2.70	2.93	3.94	4.52	4.77	4.84	4.91	4.95	4.95
1000	0.64	1.44	2.49	2.71	3.57	4.09	4.33	4.39	4.45	4.48	4.48
2000	0.56	1.28	2.18	2.42	3.07	3.54	3.77	3.85	3.89	3.92	3.92
5000	0.35	0.97	1.64	2.03	2.59	3.11	3.37	3.47	3.50	3.52	3.54
10000	0.22	0.77	1.27	1.71	2.23	2.73	2.97	3.08	3.11	3.12	3.14
20000	0.16	0.65	0.98	1.33	1.80	2.18	2.38	2.46	2.49	2.51	2.52
32730	0.12	0.52	0.79	1.06	1.44	1.74	1.91	1.98	2.02	2.03	2.05

STORM 59 - MAR 30 - APR 1, 1931
BLUE MOUNTAINS CENTER
46 00'N 118 00'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60
11	0.75	2.06	2.60	3.50	4.79	5.49	5.79	5.87	5.96	6.00	6.00
50	0.71	1.97	2.51	3.39	4.66	5.35	5.64	5.72	5.81	5.85	5.85
100	0.69	1.93	2.47	3.34	4.60	5.28	5.58	5.65	5.74	5.78	5.78
200	0.64	1.82	2.34	3.17	4.39	5.04	5.32	5.39	5.48	5.52	5.52
500	0.52	1.59	2.10	2.86	3.94	4.52	4.77	4.84	4.91	4.95	4.95
1000	0.42	1.44	1.92	2.64	3.57	4.09	4.33	4.39	4.45	4.48	4.48
1923	0.35	1.28	1.71	2.34	3.09	3.56	3.79	3.85	3.91	3.94	3.94

STORM 59 - MAR 30-APR 1, 1931
NORTH CENTRAL IDAHO CENTER
46 20'N 115 38'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60
1	0.84	1.84	3.14	3.32	3.53	3.98	4.87	5.07	5.08	5.08	5.08
10	0.84	1.84	3.14	3.32	3.53	3.98	4.87	5.07	5.08	5.08	5.08
50	0.83	1.83	3.12	3.31	3.52	3.97	4.86	5.06	5.07	5.07	5.07
100	0.79	1.74	3.00	3.21	3.43	3.84	4.73	4.95	4.96	4.96	4.97
200	0.75	1.65	2.88	3.11	3.33	3.71	4.61	4.84	4.86	4.86	4.86
500	0.70	1.53	2.70	2.93	3.15	3.50	4.35	4.58	4.60	4.60	4.60
1000	0.64	1.43	2.49	2.71	2.92	3.31	4.06	4.26	4.27	4.27	4.27
2000	0.56	1.28	2.18	2.42	2.64	3.07	3.70	3.85	3.87	3.87	3.87
2288	0.54	1.24	2.11	2.35	2.57	3.02	3.62	3.76	3.78	3.78	3.78

STORM 60 - DEC 17-19, 1931
ENTIRE STORM
47 28'N 123 35'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
1	1.22	3.82	5.31	6.79	8.06	9.64	11.79	14.00	14.24
10	1.22	3.82	5.31	6.79	8.06	9.64	11.79	14.00	14.24
50	1.18	3.70	5.30	6.75	7.98	9.51	11.54	13.73	13.96
100	1.13	3.54	5.25	6.67	7.85	9.32	11.21	13.36	13.59
200	1.06	3.30	5.08	6.45	7.54	8.91	10.60	12.67	12.89
500	0.89	2.82	4.75	5.98	6.91	8.05	9.40	11.23	11.42
1000	0.76	2.52	4.30	5.40	6.19	7.17	8.27	9.88	10.05
2000	0.64	2.15	3.67	4.60	5.28	6.11	7.03	8.39	8.54
5000	0.44	1.52	2.56	3.28	3.88	4.54	5.17	6.13	6.29
10000	0.29	1.12	1.83	2.44	3.02	3.55	3.95	4.62	4.82
20000	0.19	0.93	1.45	1.95	2.49	2.97	3.21	3.65	3.89
40221	0.13	0.67	1.01	1.39	1.81	2.18	2.32	2.57	2.78

STORM 66 - MAR 16-19, 1932
ENTIRE STORM
42 10'N 124 15'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
4	0.95	4.54	6.76	8.26	9.69	10.51	11.42	13.34	14.17	14.82	14.89	15.06	15.07
10	0.95	4.50	6.71	8.20	9.63	10.44	11.34	13.25	14.08	14.72	14.79	14.96	14.97
50	0.92	4.40	6.56	8.02	9.41	10.21	11.09	12.95	13.76	14.39	14.45	14.62	14.63
100	0.90	4.31	6.42	7.85	9.21	9.99	10.85	12.67	13.46	14.08	14.14	14.31	14.32
200	0.86	4.10	6.11	7.47	8.77	9.51	10.35	12.03	12.76	13.38	13.44	13.62	13.63
500	0.77	3.68	5.48	6.72	7.88	8.53	9.29	10.71	11.35	11.94	12.01	12.19	12.19
1000	0.70	3.31	4.93	6.05	7.08	7.66	8.36	9.59	10.16	10.71	10.79	10.95	10.96
2000	0.60	2.85	4.25	5.22	6.11	6.64	7.22	8.22	8.75	9.25	9.35	9.50	9.51
5000	0.42	2.00	3.02	3.70	4.42	4.93	5.42	6.12	6.57	7.02	7.19	7.37	7.40
10000	0.29	1.23	1.90	2.41	2.96	3.45	3.85	4.27	4.79	5.30	5.61	5.92	6.02
20000	0.21	0.85	1.46	1.95	2.38	2.72	3.13	3.46	3.93	4.38	4.74	5.05	5.21
42243	0.16	0.59	1.06	1.45	1.74	1.93	2.25	2.51	2.94	3.27	3.57	3.82	3.97

STORM 74 - DEC 19-22, 1933
ENTIRE STORM
46 10'N 122 13'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	0.95	2.73	4.70	6.56	8.17	9.23	10.38	12.41	13.57	14.75	15.57	16.43	17.02
10	0.95	2.67	4.70	6.31	7.98	8.93	9.96	11.97	13.07	14.23	14.98	16.02	16.66
50	0.85	2.59	4.68	6.16	7.83	8.71	9.67	11.66	12.72	13.85	14.56	15.69	16.37
100	0.81	2.54	4.63	6.04	7.64	8.46	9.38	11.31	12.33	13.44	14.11	15.30	15.99
200	0.78	2.47	4.55	5.91	7.43	8.19	9.06	10.92	11.90	12.97	13.61	14.83	15.53
500	0.70	2.33	4.34	5.64	7.06	7.75	8.57	10.29	11.18	12.18	12.77	13.96	14.64
1000	0.65	2.13	3.98	5.19	6.50	7.17	8.03	9.52	10.35	11.26	11.81	12.91	13.53
2000	0.59	1.94	3.41	4.53	5.81	6.49	7.60	8.67	9.42	10.22	10.70	11.67	12.21
5000	0.43	1.54	2.68	3.59	4.63	5.29	6.30	7.01	7.59	8.26	8.69	9.48	9.96
10000	0.35	1.26	2.21	3.02	3.83	4.54	5.38	6.20	6.94	7.63	8.11	8.70	9.15
11783	0.33	1.19	2.10	2.89	3.64	4.36	5.16	6.00	6.78	7.48	7.97	8.52	8.96

STORM 78 - OCT 22-25, 1934
ENTIRE STORM
46 25'N 123 31'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	0.81	3.14	4.28	5.84	6.28	7.41	7.51	8.06	9.51	10.38	10.69	11.02	11.18
10	0.81	3.14	4.28	5.84	6.28	7.41	7.51	8.03	9.51	10.38	10.69	10.99	11.18
50	0.78	3.14	4.11	5.62	6.24	7.41	7.51	7.79	9.51	10.38	10.69	10.69	11.18
100	0.71	2.97	3.93	5.40	6.24	7.41	7.51	7.67	9.51	10.38	10.69	10.69	11.18
200	0.64	2.69	3.75	5.18	5.97	7.18	7.28	7.46	9.23	10.06	10.37	10.37	10.89
500	0.58	2.30	3.47	4.83	5.64	6.79	6.89	6.99	8.61	9.34	9.65	9.65	10.19
1000	0.47	1.93	3.13	4.38	5.30	6.22	6.30	6.40	7.75	8.35	8.72	8.72	9.34
2000	0.40	1.71	2.68	3.76	4.53	5.36	5.43	5.76	6.91	7.48	7.86	7.86	8.53
5000	0.34	1.43	2.08	2.90	3.61	4.30	4.36	4.97	5.92	6.46	6.81	6.81	7.49
10000	0.27	1.14	1.79	2.48	3.19	3.78	3.85	4.48	5.30	5.76	6.04	6.07	6.62
20000	0.18	0.84	1.56	2.23	2.87	3.41	3.54	4.10	4.88	5.27	5.47	5.55	6.03
20559	0.18	0.83	1.55	2.22	2.86	3.39	3.53	4.08	4.86	5.25	5.45	5.53	6.00

STORM 78 - OCT 22-25, 1934
CASCADES CENTER
46 08'N 122 22'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	0.81	2.91	4.28	5.84	6.24	6.50	6.88	8.06	8.74	9.12	10.26	11.02	11.02
10	0.81	2.91	4.28	5.84	6.24	6.50	6.85	8.03	8.74	9.10	10.23	10.99	10.99
50	0.78	2.82	4.11	5.62	6.02	6.30	6.60	7.79	8.56	8.85	9.93	10.67	10.67
100	0.71	2.56	3.93	5.40	5.82	6.12	6.48	7.67	8.37	8.73	9.79	10.52	10.52
200	0.64	2.29	3.75	5.18	5.63	5.95	6.21	7.32	8.19	8.37	9.36	10.06	10.06
500	0.58	1.95	3.47	4.83	5.27	5.59	5.82	6.90	7.70	7.85	8.58	9.20	9.20
1000	0.47	1.72	3.13	4.38	4.77	5.15	5.38	6.35	7.03	7.22	7.66	8.17	8.20
2000	0.37	1.48	2.68	3.76	4.23	4.66	4.93	5.76	6.42	6.63	6.87	7.26	7.40
5000	0.27	1.08	2.02	2.86	3.50	3.97	4.25	4.97	5.65	5.91	6.09	6.36	6.70
7068	0.23	0.94	1.77	2.52	3.23	3.71	3.99	4.68	5.37	5.64	5.80	6.01	6.43

STORM 78 - OCT 22-25, 1934
COASTAL CENTER
46 25'N 123 31'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	0.76	3.14	3.99	4.73	6.28	7.41	7.51	7.57	9.51	10.38	10.69	10.69	11.18
10	0.76	3.14	3.99	4.73	6.28	7.41	7.51	7.57	9.51	10.38	10.69	10.69	11.18
50	0.76	3.14	3.99	4.73	6.24	7.41	7.51	7.57	9.51	10.38	10.69	10.69	11.18
100	0.71	2.97	3.85	4.73	6.24	7.41	7.51	7.57	9.51	10.38	10.69	10.69	11.18
200	0.63	2.69	3.62	4.51	5.97	7.18	7.28	7.46	9.23	10.06	10.37	10.37	10.89
500	0.52	2.30	3.28	4.32	5.64	6.79	6.89	6.99	8.61	9.34	9.65	9.65	10.19
1000	0.44	1.93	2.83	4.09	5.30	6.22	6.30	6.39	7.75	8.35	8.72	8.72	9.34
2000	0.39	1.71	2.47	3.45	4.53	5.36	5.43	5.67	6.91	7.48	7.86	7.86	8.53
5000	0.34	1.43	2.05	2.73	3.61	4.30	4.36	4.86	5.92	6.46	6.81	6.81	7.49
7221	0.31	1.28	1.90	2.59	3.35	3.95	4.00	4.56	5.50	5.99	6.31	6.31	6.90

STORM 80 - JAN 20-26, 1935
ENTIRE STORM
47 28'N 123 43'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.72	6.74	9.29	12.86	14.62	16.58	20.34	25.50	28.41	30.15	30.48	32.06	34.80
10	1.70	6.65	9.17	12.69	14.45	16.39	20.10	25.20	28.07	29.79	30.12	31.68	34.39
50	1.59	6.22	8.60	11.87	14.12	15.71	19.08	24.05	26.87	28.54	28.87	30.41	33.09
100	1.55	6.06	8.35	11.56	13.70	15.19	18.30	23.13	25.86	27.49	27.80	29.30	31.91
200	1.51	5.92	8.16	11.29	13.27	14.76	17.91	22.58	25.23	26.81	27.11	28.56	31.08
500	1.46	5.72	7.89	10.91	12.41	14.10	17.29	21.66	24.13	25.62	25.91	27.25	29.62
1000	1.36	5.35	7.49	10.27	11.72	13.26	16.07	19.85	22.02	23.41	23.70	24.83	26.92
2000	1.14	4.56	6.52	8.83	10.17	11.53	13.91	17.00	18.82	20.07	20.41	21.25	23.04
5000	0.78	3.23	4.77	6.31	7.43	8.58	10.36	12.54	13.89	14.87	15.27	15.70	16.94
10000	0.56	2.40	3.71	4.77	5.80	6.83	8.26	9.88	10.89	11.73	12.09	12.33	13.21
20000	0.41	1.79	2.84	3.55	4.49	5.41	6.57	7.77	8.54	9.21	9.53	9.70	10.20
43865	0.24	1.08	1.70	2.14	2.87	3.50	4.23	4.90	5.38	5.85	6.08	6.20	6.40

AREA (SQ. MI.)	DURATION (HR) 78	84	90	96	102	108	114	120	126	132	138	144
0	38.10	38.80	39.87	40.43	40.85	41.77	42.43	42.74	42.91	43.03	43.11	43.11
10	37.65	38.34	39.40	39.95	40.36	41.27	41.93	42.23	42.40	42.52	42.60	42.60
50	36.30	36.97	38.01	38.55	38.99	39.96	40.61	40.92	41.14	41.28	41.36	41.36
100	35.04	35.68	36.70	37.22	37.67	38.64	39.28	39.57	39.81	39.96	40.03	40.03
200	34.10	34.73	35.71	36.21	36.63	37.55	38.16	38.45	38.66	38.79	38.87	38.87
500	32.47	33.08	34.01	34.50	34.89	35.77	36.36	36.64	36.83	36.95	37.02	37.02
1000	29.48	30.13	30.99	31.49	31.84	32.68	33.28	33.63	33.83	33.95	34.01	34.01
2000	25.25	25.91	26.69	27.24	27.53	28.33	28.94	29.37	29.66	29.83	29.90	29.90
5000	18.50	19.12	19.70	20.19	20.55	20.89	21.44	21.80	22.16	22.36	22.48	22.51
10000	14.39	15.17	15.74	16.30	16.59	16.74	17.21	17.61	17.90	18.07	18.17	18.21
20000	11.01	11.73	12.20	12.68	12.92	13.02	13.31	13.60	13.85	13.98	14.05	14.08
43865	6.79	7.21	7.53	7.79	7.93	7.99	8.11	8.27	8.42	8.48	8.52	8.54

STORM 80 - JAN 20-26, 1935

OLYMPIC PENINSULA CENTER

47 28'N 123 43'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.72	6.74	9.29	12.86	14.62	16.58	20.34	25.50	28.41	30.15	30.48	32.06	34.80
10	1.70	6.65	9.17	12.69	14.45	16.39	20.10	25.20	28.07	29.79	30.12	31.68	34.39
50	1.59	6.22	8.60	11.87	14.12	15.71	19.08	24.05	26.87	28.54	28.87	30.41	33.09
100	1.55	6.06	8.35	11.56	13.70	15.19	18.30	23.13	25.86	27.49	27.80	29.30	31.91
200	1.51	5.92	8.16	11.29	13.27	14.76	17.91	22.58	25.23	26.81	27.11	28.56	31.08
500	1.46	5.72	7.89	10.91	12.41	14.10	17.29	21.66	24.13	25.62	25.91	27.25	29.62
1000	1.36	5.35	7.49	10.27	11.72	13.26	16.07	19.85	22.02	23.41	23.70	24.83	26.92
2000	1.14	4.56	6.52	8.83	10.17	11.53	13.91	17.00	18.82	20.07	20.41	21.25	23.04
5000	0.78	3.23	4.77	6.31	7.43	8.58	10.36	12.54	13.89	14.87	15.27	15.70	16.94
5987	0.72	2.98	4.42	5.81	6.87	7.97	9.64	11.62	12.85	13.75	14.17	14.50	15.60

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	78	84	90	96	102	108	114	120	126	132	138	144
1	38.10	38.80	39.87	40.43	40.85	41.77	42.43	42.74	42.91	43.03	43.11	43.11
10	37.65	38.34	39.40	39.95	40.36	41.27	41.93	42.23	42.40	42.52	42.60	42.60
50	36.30	36.97	38.01	38.55	38.99	39.96	40.61	40.92	41.14	41.28	41.36	41.36
100	35.04	35.68	36.70	37.22	37.67	38.64	39.28	39.57	39.81	39.96	40.03	40.03
200	34.10	34.73	35.71	36.21	36.63	37.55	38.16	38.45	38.66	38.79	38.87	38.87
500	32.47	33.08	34.01	34.50	34.89	35.77	36.36	36.64	36.83	36.95	37.02	37.02
1000	29.48	30.13	30.99	31.49	31.84	32.68	33.28	33.63	33.83	33.95	34.01	34.01
2000	25.25	25.91	26.69	27.24	27.53	28.33	28.94	29.37	29.66	29.83	29.90	29.90
5000	18.50	19.12	19.70	20.19	20.55	20.89	21.44	21.80	22.16	22.36	22.48	22.51
5987	16.99	17.60	18.12	18.58	18.95	19.17	19.72	20.06	20.40	20.62	20.75	20.80

STORM 80 - JAN 20-26, 1935

NORTH CASCADES CENTER

48 00'N 121 28'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.15	3.92	5.88	7.73	8.53	9.25	10.20	11.53	12.50	13.26	14.20	15.62	17.26
10	1.11	3.76	5.65	7.43	8.20	8.98	9.90	11.19	12.14	13.26	14.20	15.01	16.61
50	1.02	3.47	5.32	7.13	7.87	8.41	9.44	10.71	11.57	13.12	14.05	14.64	16.19
100	0.98	3.35	5.17	7.01	7.73	8.14	9.14	10.55	11.41	12.70	13.60	14.31	15.99
200	0.94	3.20	4.96	6.74	7.44	7.84	8.89	10.25	11.09	11.86	12.70	13.83	15.47
500	0.79	2.66	4.28	6.02	6.66	7.50	8.53	9.77	10.58	11.10	11.36	12.73	14.41
1000	0.66	2.24	3.61	5.07	5.90	6.75	7.86	9.01	9.81	10.31	10.56	11.25	12.71
2000	0.60	2.06	3.26	4.52	5.20	6.09	7.22	8.20	9.03	9.73	10.07	10.41	11.66
4279	0.48	1.65	2.62	3.69	4.40	5.40	6.44	7.31	8.11	8.84	9.21	9.30	10.12

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	78	84	90	96	102	108	114	120	126	132	138	144
0	18.43	19.75	21.53	22.80	22.80	23.16	24.61	26.26	26.26	26.26	26.26	26.26
10	17.89	19.75	21.53	22.80	22.80	23.16	24.61	26.26	26.26	26.26	26.26	26.26
50	17.56	19.55	21.30	22.57	22.57	22.92	24.35	25.99	25.99	25.99	25.99	25.99
100	16.98	18.89	20.59	21.81	21.83	22.16	23.52	25.10	25.12	25.13	25.13	25.13
200	16.41	17.61	19.18	20.32	20.36	20.66	21.90	23.36	23.40	23.43	23.44	23.44
500	15.40	16.47	17.86	18.52	18.56	18.76	19.03	20.23	20.31	20.36	20.38	20.38
1000	13.63	14.67	16.06	16.70	16.74	16.92	17.16	18.05	18.15	18.21	18.24	18.24
2000	12.50	13.63	14.98	15.67	15.73	15.89	16.19	16.94	17.03	17.08	17.10	17.10
4279	10.86	12.02	13.21	13.89	13.96	14.12	14.39	15.11	15.18	15.22	15.23	15.23

STORM 82 - MAR 24-25, 1935
ENTIRE STORM
47 22'N 115 26'W

AREA (SQ. MI.) / DURATION

AREA (SQ. MI.)	1	6	12	18	24
15	0.45	2.03	3.16	3.61	4.06
50	0.43	1.94	3.01	3.44	3.87
100	0.41	1.85	2.88	3.29	3.70
200	0.38	1.72	2.68	3.06	3.44
500	0.32	1.43	2.23	2.54	2.86
1000	0.27	1.21	1.88	2.15	2.44
2000	0.22	1.00	1.55	1.78	2.04
5000	0.18	0.70	1.18	1.40	1.67
10000	0.15	0.49	0.91	1.12	1.39
20000	0.11	0.37	0.68	0.85	1.08
23729	0.10	0.34	0.62	0.78	1.01

STORM 88 - DEC 26-30, 1937
ENTIRE STORM
44 55'N 44 55'N

AREA (SQ. MI.) / DURATION

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.17	3.38	5.90	8.40	10.94	13.35	15.31	16.47	17.56	17.56	17.56	19.83	20.71
10	1.17	3.32	5.80	8.26	10.76	13.13	15.05	16.19	17.26	17.26	17.26	19.49	20.36
50	1.12	3.23	5.64	8.03	10.46	12.76	14.63	15.74	16.78	16.78	16.78	18.95	19.79
100	1.02	3.07	5.40	7.66	9.98	12.21	14.01	15.07	16.05	16.05	16.05	18.13	18.95
200	0.90	2.84	4.96	6.95	9.09	11.14	12.80	13.75	14.62	14.62	14.62	16.51	17.31
500	0.74	2.44	4.20	5.72	7.40	9.12	10.53	11.37	12.02	12.06	12.14	13.64	14.58
1000	0.58	2.18	3.58	4.84	6.43	7.72	8.91	10.15	10.72	11.04	11.59	12.53	13.27
2000	0.54	2.02	3.19	4.43	5.89	7.17	8.19	9.10	9.60	9.85	10.39	11.23	12.00
5000	0.45	1.69	2.59	3.70	4.87	5.95	6.82	7.59	7.99	8.07	8.51	9.17	9.92
10000	0.34	1.33	2.31	3.33	4.31	5.23	6.00	6.65	7.00	7.13	7.54	8.18	8.99
13869	0.29	1.16	2.18	3.16	4.04	4.89	5.63	6.22	6.55	6.70	7.10	7.72	8.57

AREA (SQ. MI.) / DURATION

AREA (SQ. MI.)	78	84	90	96
0	22.67	24.80	26.80	27.08
10	22.28	24.38	26.34	26.61
50	21.67	23.71	25.62	25.88
100	20.80	22.78	24.63	24.88
200	19.10	20.95	22.67	22.90
500	16.12	17.75	19.25	19.49
1000	14.55	15.97	17.24	17.71
2000	13.13	14.51	15.70	16.15
5000	10.92	12.15	13.22	13.55
10000	9.90	10.93	11.81	12.18
13869	9.44	10.37	11.16	11.55

STORM 88 - DEC 26-30, 1937
COASTAL OREGON CENTER REVISED
44 55'N 123 30'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.17	3.38	5.90	8.40	10.94	13.35	15.31	16.47	17.56	17.56	17.56	19.83	20.71
10	1.17	3.32	5.80	8.26	10.76	13.13	15.05	16.19	17.26	17.26	17.26	19.49	20.36
50	1.12	3.23	5.64	8.03	10.46	12.76	14.63	15.74	16.78	16.78	16.78	18.95	19.79
100	1.02	3.07	5.40	7.66	9.98	12.21	14.01	15.07	16.05	16.05	16.05	18.13	18.95
200	0.90	2.84	4.96	6.95	9.09	11.14	12.80	13.75	14.62	14.62	14.62	16.51	17.31
500	0.74	2.44	4.20	5.72	7.40	9.12	10.53	11.37	12.02	12.06	12.14	13.64	14.58
1000	0.58	2.18	3.58	4.84	6.43	7.72	8.91	10.15	10.72	11.04	11.59	12.53	13.27
2000	0.54	2.02	3.19	4.43	5.89	7.17	8.19	9.10	9.60	9.85	10.39	11.23	12.00
5000	0.45	1.69	2.59	3.70	4.87	5.95	6.82	7.59	7.99	8.07	8.51	9.17	9.92
5103	0.44	1.68	2.58	3.68	4.84	5.91	6.77	7.54	7.94	8.01	8.45	9.11	9.85

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	78	84	90	96
0	22.67	24.80	26.80	27.08
10	22.28	24.38	26.34	26.61
50	21.67	23.71	25.62	25.88
100	20.80	22.78	24.63	24.88
200	19.10	20.95	22.67	22.90
500	16.12	17.75	19.25	19.49
1000	14.55	15.97	17.24	17.71
2000	13.13	14.51	15.70	16.15
5000	10.92	12.15	13.22	13.55
5103	10.85	12.07	13.13	13.46

STORM 88 - DEC 26-30, 1937
CASCADES CENTER REVISED MASS CURVES NEAR COUGAR, WA
46 05'N 122 18'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	0.69	2.96	5.08	6.38	7.35	8.37	9.59	10.15	11.31	11.99	12.75	13.31	14.05
10	0.64	2.96	5.08	6.24	7.30	8.37	9.59	10.15	11.31	11.99	12.75	13.31	14.05
50	0.58	2.67	4.53	5.81	6.73	7.70	8.86	9.93	10.53	11.08	12.13	12.55	13.04
100	0.55	2.45	4.17	5.55	6.45	7.33	8.28	9.72	10.31	10.85	11.88	12.33	12.88
200	0.53	2.14	3.79	5.19	6.11	7.07	8.04	9.39	9.95	10.48	11.48	11.97	12.62
500	0.47	1.78	3.41	4.66	5.61	6.55	7.49	8.61	9.16	9.66	10.54	11.08	12.14
1000	0.40	1.58	3.00	4.13	4.93	5.77	6.63	7.52	8.00	8.44	9.22	10.11	11.27
2000	0.32	1.37	2.58	3.58	4.41	5.05	5.74	6.43	6.82	7.23	8.13	9.20	10.29
4685	0.22	1.11	2.06	2.92	3.77	4.58	5.36	6.03	6.38	6.71	7.45	8.32	9.17

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	78	84	90	96
1	14.80	15.36	16.37	17.39
10	14.80	15.33	16.37	17.39
50	13.97	14.93	16.37	17.39
100	13.84	14.79	16.19	17.21
200	13.64	14.59	15.90	16.92
500	13.18	14.14	15.24	16.20
1000	12.27	13.19	14.10	14.95
2000	11.25	12.07	12.85	13.55
4685	9.99	10.62	11.36	11.88

STORM 106 - JUNE 26-27, 1944
REVISED ENTIRE STORM
44 16'N 112 04'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24
4	0.97	2.71	3.05	3.93	4.27
10	0.96	2.70	3.04	3.91	4.25
50	0.94	2.63	2.96	3.81	4.14
100	0.92	2.58	2.92	3.75	4.07
200	0.89	2.50	2.83	3.64	3.95
500	0.84	2.37	2.68	3.45	3.75
1000	0.76	2.17	2.47	3.18	3.48
2000	0.60	1.77	2.15	2.84	3.15
5000	0.36	1.23	1.77	2.23	2.68
10000	0.26	0.97	1.51	1.92	2.36
20000	0.17	0.75	1.24	1.67	2.06
41385	0.12	0.57	0.99	1.34	1.68

STORM 126 - OCT 26-29, 1950
ENTIRE STORM
41 52'N 123 58'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.84	6.44	11.47	13.47	15.84	16.50	17.96	18.96	19.37	19.98	20.69	20.93	21.17
10	1.84	6.44	11.47	13.47	15.84	16.50	17.96	18.96	19.37	19.98	20.69	20.93	21.17
50	1.77	6.20	11.05	13.00	15.31	15.98	17.42	18.46	18.89	19.47	20.19	20.46	20.72
100	1.58	5.63	10.12	11.98	14.21	14.95	16.47	17.68	18.30	18.88	19.56	19.97	20.35
200	1.31	4.80	8.76	10.51	12.62	13.49	15.14	16.61	17.51	18.19	18.71	19.33	19.89
500	1.01	3.91	7.05	9.03	11.02	11.78	13.69	15.65	16.88	17.71	17.90	18.73	19.18
1000	0.86	3.13	5.57	7.52	9.29	9.99	12.19	14.55	15.97	17.02	17.17	17.90	18.29
2000	0.72	2.68	4.85	6.32	7.77	9.00	11.34	13.24	14.57	15.73	15.90	16.62	17.03
5000	0.56	2.30	4.14	5.40	6.59	8.02	9.62	10.96	12.17	13.17	13.39	14.17	14.57
10000	0.45	1.89	3.41	4.58	5.68	7.02	8.41	9.51	10.56	11.26	11.47	12.23	12.65
20000	0.34	1.49	2.71	3.83	4.88	6.17	7.44	8.35	9.25	9.74	9.96	10.67	11.15
50000	0.20	1.02	1.93	2.79	3.65	4.42	5.29	5.93	6.54	6.89	7.11	7.67	8.18
80511	0.14	0.75	1.42	2.09	2.75	3.28	3.88	4.36	4.75	5.02	5.34	5.78	6.21

STORM 133 - NOV 2-4, 1955
ENTIRE STORM
47 34'N 123 28'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48
1	1.22	4.28	8.02	10.15	12.16	13.36	15.12	16.10	17.27
10	1.19	4.28	8.02	10.15	12.16	13.36	15.12	16.10	17.27
50	1.06	4.26	8.02	10.15	12.16	13.36	15.12	16.10	17.27
100	0.94	4.26	8.02	10.15	12.16	13.36	15.12	16.10	17.27
200	0.89	4.22	7.91	10.05	12.06	13.26	15.00	15.98	17.15
500	0.83	4.01	7.35	9.45	11.41	12.62	14.27	15.21	16.30
1000	0.74	3.67	6.67	8.56	10.42	11.68	13.15	14.08	15.04
2000	0.63	3.27	5.86	7.55	9.31	10.65	11.90	12.75	13.58
5000	0.47	2.51	4.55	5.93	7.35	8.43	9.48	10.09	10.74
10000	0.34	1.86	3.51	4.69	5.70	6.46	7.39	7.89	8.48
20000	0.26	1.45	2.72	3.68	4.48	5.08	5.78	6.21	6.69
41818	0.17	0.94	1.79	2.45	2.89	3.31	3.64	4.03	4.34

STORM 133 - NOV 2-4, 1955
OLYMPIC PENINSULA CENTER
47 59'N 121 20'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48
1	0.90	4.26	8.02	10.15	12.16	13.36	15.12	16.10	17.27
10	0.90	4.26	8.02	10.15	12.16	13.36	15.12	16.10	17.27
50	0.90	4.26	8.02	10.15	12.16	13.36	15.12	16.10	17.27
100	0.90	4.26	8.02	10.15	12.16	13.36	15.12	16.10	17.27
200	0.89	4.22	7.91	10.05	12.06	13.26	15.00	15.98	17.15
500	0.83	4.01	7.35	9.45	11.41	12.62	14.27	15.21	16.30
1000	0.74	3.67	6.67	8.56	10.42	11.68	13.15	14.08	15.04
2000	0.63	3.27	5.86	7.55	9.31	10.65	11.90	12.75	13.56
5000	0.47	2.51	4.55	5.93	7.35	8.43	9.48	10.09	10.74
7883	0.37	1.98	3.75	5.00	6.06	6.87	7.84	8.37	8.98

STORM 133 - NOV 2-4, 1955
NORTH CASCADES CENTER
47 59'N 121 20'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48
6	1.12	4.28	6.30	7.88	9.01	10.31	11.50	12.85	13.23
10	1.12	4.28	6.30	7.88	9.01	10.31	11.50	12.85	13.23
50	1.03	4.15	6.11	7.66	8.75	10.04	11.29	12.59	12.95
100	0.94	4.01	5.91	7.42	8.48	9.74	11.01	12.26	12.63
200	0.89	3.85	5.68	7.13	8.16	9.34	10.50	11.75	12.17
500	0.77	3.44	5.19	6.52	7.61	8.55	9.69	10.82	11.34
1000	0.65	2.97	4.57	5.82	6.94	7.79	8.88	9.86	10.41
2000	0.48	2.30	3.70	4.91	6.01	6.96	7.93	8.78	9.20
3997	0.35	1.79	2.97	4.09	5.02	5.83	6.64	7.30	7.62

STORM 143 - OCT 1-2, 1957
REVISED ENTIRE STORM
45 49'N 119 17'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24
3	0.58	2.00	3.06	3.24	3.43
10	0.57	1.98	3.03	3.21	3.40
50	0.55	1.90	2.92	3.09	3.27
100	0.54	1.87	2.87	3.03	3.22
200	0.53	1.84	2.82	2.98	3.16
500	0.47	1.65	2.57	2.73	2.88
1000	0.37	1.44	2.30	2.46	2.62
2000	0.28	1.22	2.02	2.20	2.35
5000	0.19	0.94	1.61	1.81	1.96
10000	0.14	0.71	1.29	1.50	1.65
20000	0.09	0.51	0.94	1.13	1.28
22002	0.09	0.48	0.89	1.07	1.23

STORM 147 - DEC 14-16, 1959
ENTIRE STORM
47 33'N 121 20'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48
1	0.70	3.41	5.33	6.57	8.48	10.00	10.77	11.04	11.18
10	0.70	3.41	5.33	6.57	8.48	10.00	10.77	11.04	11.18
50	0.69	3.41	5.33	6.57	8.44	9.95	10.72	10.99	11.12
100	0.69	3.41	5.33	6.57	8.22	9.69	10.44	10.71	10.83
200	0.69	3.41	5.33	6.57	7.94	9.36	10.07	10.35	10.46
500	0.66	3.27	5.16	6.37	7.53	8.86	9.54	9.83	9.93
1000	0.62	3.04	4.86	6.04	7.02	8.26	8.89	9.18	9.28
2000	0.52	2.49	4.31	5.43	6.40	7.49	8.04	8.33	8.41
5000	0.36	1.82	3.29	4.26	5.24	6.06	6.58	6.81	6.87
10000	0.26	1.38	2.52	3.33	4.12	4.77	5.19	5.37	5.41
20000	0.21	1.13	2.09	2.78	3.45	4.07	4.48	4.64	4.67
29329	0.18	1.00	1.85	2.48	3.07	3.69	4.08	4.24	4.26

STORM 149 - NOV 21-24, 1961
ENTIRE STORM
42 10'N 123 56'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.11	3.91	6.80	9.35	11.18	12.22	13.10	13.96	15.12	15.72	16.68	16.93	17.00
10	0.94	3.55	6.27	8.89	10.90	12.01	13.00	13.67	14.72	15.46	16.43	16.74	16.85
50	0.78	3.34	5.89	8.38	10.56	11.66	12.77	13.34	14.18	15.06	16.01	16.38	16.51
100	0.74	3.22	5.67	8.12	10.18	11.24	12.34	12.93	13.75	14.66	15.56	15.96	16.09
200	0.70	3.06	5.42	7.68	9.47	10.48	11.64	12.36	13.12	14.18	14.97	15.41	15.53
500	0.63	2.86	5.10	7.05	8.86	10.00	11.35	12.16	12.83	13.89	14.64	15.01	15.13
1000	0.58	2.70	4.86	6.58	8.38	9.59	11.06	11.93	12.55	13.63	14.34	14.67	14.79
2000	0.49	2.47	4.53	6.10	7.57	8.71	10.02	10.87	11.71	12.78	13.43	13.71	13.80
5000	0.34	1.94	3.62	4.95	6.42	7.61	8.57	9.40	10.30	11.22	11.81	12.09	12.17
10000	0.28	1.61	2.98	4.21	5.64	6.76	7.62	8.46	9.17	9.96	10.57	10.86	10.97
20000	0.23	1.30	2.40	3.38	4.65	5.66	6.42	7.19	7.74	8.32	8.90	9.20	9.32
20850	0.23	1.28	2.36	3.32	4.57	5.58	6.33	7.09	7.63	8.19	8.77	9.07	9.20

STORM 149 - NOV 21-24, 1961
OREGON CASCADES CENTER
43 28'N 122 56'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.02	3.91	6.35	7.24	8.88	9.70	10.92	11.53	12.26	12.84	13.62	13.98	14.08
10	0.89	3.54	5.78	6.66	8.23	9.35	10.39	11.53	12.26	12.84	13.62	13.98	14.08
50	0.64	2.67	4.67	6.34	8.00	9.23	10.28	11.39	12.13	12.72	13.48	13.83	13.94
100	0.62	2.56	4.52	6.17	7.83	9.06	10.12	11.21	11.95	12.56	13.29	13.64	13.76
200	0.57	2.32	4.20	5.77	7.39	8.62	9.69	10.70	11.44	12.09	12.76	13.09	13.22
500	0.49	2.06	3.80	5.16	6.67	7.86	8.88	9.84	10.58	11.21	11.83	12.15	12.28
1000	0.42	1.93	3.58	4.75	6.19	7.35	8.35	9.33	10.08	10.68	11.34	11.67	11.79
2000	0.35	1.79	3.35	4.34	5.71	6.83	7.82	8.83	9.59	10.16	10.85	11.18	11.30
3473	0.30	1.67	3.17	4.07	5.38	6.48	7.40	8.35	9.07	9.59	10.24	10.55	10.67

STORM 149 - NOV 21-24, 1961
SOUTH COASTAL OREGON CENTER
42 10'N 123 56'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
2	1.11	3.70	6.80	9.35	11.18	12.22	13.10	13.96	15.12	15.72	16.68	16.93	17.00
10	0.94	3.55	6.29	8.89	10.90	12.01	13.00	13.67	14.72	15.46	16.43	16.74	16.85
50	0.78	3.34	5.89	8.38	10.56	11.66	12.77	13.34	14.18	15.06	16.01	16.38	16.51
100	0.74	3.22	5.67	8.12	10.18	11.24	12.34	12.93	13.75	14.66	15.56	15.96	16.09
200	0.70	3.06	5.42	7.68	9.47	10.48	11.64	12.36	13.12	14.18	14.97	15.41	15.53
500	0.63	2.86	5.10	7.05	8.86	10.00	11.35	12.16	12.83	13.89	14.64	15.01	15.13
1000	0.58	2.70	4.86	6.58	8.38	9.59	11.06	11.93	12.55	13.63	14.34	14.67	14.79
2000	0.49	2.47	4.53	6.10	7.57	8.71	10.02	10.87	11.71	12.78	13.43	13.71	13.80
5000	0.34	1.94	3.62	4.95	6.42	7.61	8.57	9.40	10.30	11.22	11.81	12.09	12.17
5936	0.32	1.84	3.44	4.71	6.13	7.30	8.21	9.02	9.87	10.76	11.35	11.65	11.73

STORM 151 - NOV 18-20, 1962
ENTIRE STORM
47 28'N 123 43'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
2	1.05	4.74	7.91	10.45	12.45	12.96	12.98	13.11	13.22
10	1.05	4.74	7.91	10.45	12.45	12.96	12.98	13.11	13.22
50	1.03	4.66	7.78	10.27	12.25	12.75	12.77	12.89	13.00
100	1.00	4.55	7.60	10.02	11.95	12.44	12.46	12.57	12.68
200	0.97	4.38	7.32	9.62	11.48	11.95	11.97	12.08	12.19
500	0.88	4.01	6.72	8.79	10.57	11.03	11.05	11.17	11.28
1000	0.73	3.50	5.89	7.68	9.37	9.87	9.90	10.05	10.18
2000	0.58	2.88	4.97	6.57	7.95	8.50	8.59	8.80	8.94
5000	0.46	2.15	3.87	5.15	6.15	6.94	7.30	7.62	7.78
10000	0.36	1.86	3.45	4.66	5.53	6.20	6.55	6.92	7.10
20000	0.29	1.56	3.04	4.16	5.09	5.60	5.90	6.20	6.41
36321	0.22	1.14	2.25	3.10	3.80	4.19	4.51	4.78	4.94

STORM 151 - NOV 18-20, 1962
NORTH WASHINGTON CASCADES CENTER
48 41'N 121 33'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
2	0.86	4.67	7.76	9.33	10.56	11.14	11.14	11.14	11.21
10	0.86	4.67	7.76	9.33	10.56	11.14	11.14	11.14	11.21
50	0.82	4.38	7.42	8.96	10.13	10.67	10.67	10.67	10.79
100	0.79	4.22	7.19	8.69	9.82	10.34	10.34	10.34	10.48
200	0.77	4.08	6.95	8.38	9.47	9.97	9.97	9.97	10.11
500	0.72	3.83	6.52	7.84	8.87	9.33	9.33	9.33	9.48
1000	0.63	3.36	5.77	7.06	7.98	8.42	8.45	8.48	8.66
2000	0.54	2.82	4.92	6.29	7.08	7.55	7.64	7.76	8.00
4960	0.41	2.16	3.88	5.16	5.81	6.22	6.36	6.58	6.83

STORM 151 - NOV 18-20, 1962
COASTAL CENTER
47 28'N 123 43'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
2	1.05	4.74	7.91	10.45	12.45	12.96	12.98	13.11	13.22
10	1.05	4.74	7.91	10.45	12.45	12.96	12.98	13.11	13.22
50	1.03	4.66	7.78	10.27	12.25	12.75	12.77	12.89	13.00
100	1.00	4.55	7.60	10.02	11.95	12.44	12.46	12.57	12.68
200	0.97	4.38	7.32	9.62	11.48	11.95	11.97	12.08	12.19
500	0.88	4.01	6.72	8.79	10.57	11.03	11.05	11.17	11.28
1000	0.73	3.50	5.89	7.68	9.37	9.87	9.90	10.05	10.18
2000	0.58	2.86	4.94	6.57	7.95	8.50	8.59	8.80	8.94
4665	0.38	1.94	3.64	5.10	6.21	7.02	7.37	7.69	7.85

STORM 151 - NOV 18-20, 1962
SOUTH WASHINGTON CASCADES CENTER
46 43'N 121 43'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
4	0.90	3.37	5.31	6.63	7.64	8.42	8.74	9.08	9.26
10	0.90	3.37	5.31	6.63	7.64	8.42	8.74	9.08	9.26
50	0.89	3.21	5.28	6.61	7.55	8.37	8.72	9.08	9.26
100	0.84	3.07	5.12	6.50	7.52	8.33	8.67	9.04	9.22
200	0.81	2.96	4.96	6.32	7.29	8.07	8.41	8.78	8.95
500	0.72	2.75	4.75	6.10	6.98	7.69	8.02	8.38	8.54
1000	0.64	2.54	4.59	5.95	6.73	7.36	7.68	8.02	8.16
2000	0.58	2.32	4.36	5.70	6.37	6.93	7.26	7.56	7.68
2710	0.57	2.21	4.15	5.45	6.07	6.61	6.94	7.23	7.35

STORM 155 - JUNE 6-8, 1964
ENTIRE STORM
48 34'N 113 23'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
1	1.11	5.93	9.78	12.80	14.35	14.81	15.31	15.31	15.31
10	1.11	5.93	9.78	12.80	14.35	14.81	15.31	15.31	15.31
50	1.09	5.80	9.56	12.52	14.04	14.49	14.98	14.98	14.98
100	1.06	5.64	9.29	12.17	13.65	14.09	14.56	14.56	14.56
200	0.99	5.26	8.77	11.50	12.96	13.40	13.87	13.89	13.89
500	0.88	4.56	7.93	10.44	11.93	12.39	12.86	12.92	12.92
1000	0.79	3.94	7.23	9.57	11.07	11.57	12.00	12.11	12.13
2000	0.70	3.38	6.59	8.70	10.09	10.61	11.02	11.17	11.27
5000	0.55	2.73	5.31	7.01	8.13	8.58	8.89	9.03	9.14
10000	0.41	2.14	4.15	5.47	6.37	6.76	6.97	7.09	7.18
20000	0.31	1.57	3.02	4.05	4.74	5.14	5.32	5.42	5.48
50000	0.20	1.03	1.88	2.61	3.06	3.38	3.52	3.60	3.67
87054	0.13	0.69	1.30	1.82	2.17	2.45	2.60	2.66	2.71

STORM 155 - JUNE 6-8, 1964
STORM PORTION WEST OF CONTINENTAL DIVIDE
LAT/LON NOT AVAILABLE

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
3	1.02	5.42	8.92	11.69	13.10	13.52	13.98	13.98	13.98
10	0.95	5.02	8.47	11.11	12.44	12.87	13.29	13.31	13.31
50	0.83	4.44	7.79	10.25	11.45	11.88	12.27	12.32	12.32
100	0.78	4.21	7.51	9.90	11.03	11.48	11.85	11.91	11.91
200	0.73	3.94	7.16	9.41	10.48	10.93	11.29	11.36	11.36
500	0.64	3.44	6.30	8.20	9.12	9.54	9.87	9.99	10.02
1000	0.54	2.89	5.35	6.90	7.68	8.06	8.35	8.53	8.58
2000	0.44	2.36	4.32	5.49	6.13	6.42	6.68	6.87	6.94
5000	0.35	1.84	3.13	3.88	4.35	4.55	4.73	4.90	4.98
10000	0.29	1.50	2.47	3.07	3.44	3.60	3.74	3.90	3.97
20000	0.23	1.15	1.85	2.31	2.57	2.70	2.81	2.94	3.02
34002	0.17	0.86	1.44	1.77	1.97	2.08	2.16	2.28	2.35

STORM 156 - DEC 21-24, 1964
ENTIRE STORM
39 55'N 123 35'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
0	2.05	6.11	9.74	14.26	17.32	19.39	21.65	25.42	27.14	28.04	28.41	28.85	30.32
10	2.05	5.70	8.76	13.08	16.23	18.53	20.74	24.21	26.13	27.13	27.42	27.89	30.29
50	1.93	5.39	8.59	11.83	14.99	17.53	20.10	22.94	25.05	26.05	26.24	27.06	29.22
100	1.72	5.14	8.22	11.33	14.46	17.11	19.66	22.45	24.63	25.60	25.75	26.60	28.60
200	1.59	4.90	7.76	10.86	13.94	16.64	19.06	21.76	23.94	24.87	25.01	25.82	27.64
500	1.27	4.28	7.07	9.98	12.85	15.49	17.63	20.16	22.21	23.04	23.21	23.96	25.65
1000	0.97	3.63	6.38	9.06	11.65	13.91	15.83	18.10	19.94	20.65	20.81	21.56	22.96
2000	0.71	3.21	5.97	8.48	10.77	12.69	14.50	16.61	18.36	19.04	19.61	20.27	21.73
5000	0.57	2.72	5.29	7.55	9.47	11.03	12.58	14.37	15.84	16.40	16.62	17.09	18.39
10000	0.46	2.51	4.82	7.01	8.85	10.21	11.66	13.43	14.63	15.24	15.47	15.93	17.12
20000	0.36	1.96	3.82	5.69	7.28	8.40	9.86	11.37	12.33	12.80	12.98	13.34	14.33
50000	0.28	1.54	3.02	4.44	5.72	6.69	7.78	9.05	9.97	10.59	10.80	11.21	12.19
99988	0.20	1.11	2.19	3.26	4.22	4.98	5.77	6.72	7.46	7.96	8.11	8.43	9.19

STORM 156 - DEC 21-24, 1964
NORTHWESTERN CALIFORNIA CENTER
39 55'N 123 35'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
0	2.05	6.11	9.74	14.26	17.32	19.39	21.65	25.42	27.14	28.04	28.41	28.85	30.32
10	2.05	5.70	8.64	13.08	16.23	18.53	20.74	24.21	26.13	27.13	27.42	27.89	30.29
50	1.93	5.21	8.15	11.83	14.99	17.53	20.10	22.94	25.05	26.05	26.24	27.06	29.22
100	1.72	5.11	8.05	11.33	14.46	17.11	19.66	22.45	24.63	25.60	25.75	26.60	28.60
200	1.59	4.90	7.76	10.86	13.94	16.64	19.06	21.76	23.94	24.87	25.01	25.82	27.64
500	1.27	4.28	7.07	9.98	12.85	15.49	17.63	20.16	22.21	23.04	23.21	23.96	25.65
1000	0.97	3.63	6.38	9.06	11.65	13.91	15.83	18.10	19.94	20.65	20.81	21.46	22.96
2000	0.71	3.04	5.97	8.48	10.77	12.69	14.50	16.61	18.36	18.94	19.11	19.65	21.03
5000	0.57	2.72	5.29	7.55	9.47	11.03	12.58	14.37	15.84	16.40	16.55	16.98	18.18
10000	0.46	2.51	4.82	7.01	8.85	10.21	11.66	13.43	14.63	15.24	15.47	15.93	17.12
20000	0.36	1.96	3.82	5.69	7.28	8.40	9.86	11.37	12.33	12.80	12.98	13.34	14.33
20120	0.36	1.95	3.81	5.68	7.27	8.38	9.83	11.34	12.30	12.77	12.95	13.31	14.30

STORM 156 - DEC 21-24, 1964
NORTH COASTAL OREGON CENTER
44 55'N 123 36'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
2	0.85	3.23	5.60	7.52	8.84	10.63	12.59	13.12	15.39	16.19	16.19	17.15	18.31
10	0.85	3.23	5.60	7.52	8.84	10.63	12.59	13.12	15.39	16.19	16.19	17.15	18.31
50	0.81	2.79	5.16	7.15	8.36	10.17	12.01	12.58	14.85	15.64	15.65	16.60	17.84
100	0.76	2.67	4.89	6.76	7.90	9.69	11.41	12.04	14.24	15.01	15.03	15.95	17.19
200	0.66	2.57	4.48	6.15	7.38	9.11	10.46	11.24	13.27	13.98	14.00	14.86	16.03
500	0.55	2.27	3.95	5.59	6.86	8.47	9.16	10.09	11.58	11.85	11.86	12.57	14.13
1000	0.51	2.11	3.53	4.94	6.00	7.40	8.25	9.10	10.54	11.07	11.09	11.76	12.83
2000	0.47	1.97	3.31	4.61	5.56	6.81	7.84	8.72	9.98	10.45	10.46	11.08	12.23
2757	0.45	1.91	3.21	4.46	5.36	6.54	7.65	8.54	9.73	10.16	10.17	10.77	11.95

STORM 156 - DEC 21-24, 1964
OREGON CASCADES CENTER
44 40'N 121 49'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.29	3.62	6.04	7.84	9.40	10.75	12.43	14.17	15.03	16.73	17.47	18.64	20.33
10	1.26	3.61	6.02	7.81	9.38	10.72	12.40	14.13	14.99	16.69	17.42	18.58	20.28
50	1.19	3.42	5.70	7.40	8.88	10.16	11.75	13.39	14.21	15.81	16.51	17.62	19.22
100	1.14	3.17	5.33	6.92	8.27	9.58	11.06	12.55	13.41	14.91	15.58	16.69	18.21
200	1.00	2.82	4.80	6.23	7.77	8.94	10.07	11.36	12.26	13.61	14.23	15.32	16.72
500	0.75	2.44	4.31	5.69	7.19	8.18	9.33	10.53	11.52	12.76	13.31	14.54	15.90
1000	0.63	2.16	3.97	5.30	6.76	7.69	8.81	9.95	11.02	12.20	12.69	14.07	15.40
2000	0.50	1.97	3.54	4.97	6.33	7.29	8.18	9.36	10.34	11.49	11.85	13.12	14.50
5000	0.34	1.75	3.25	4.53	5.76	6.76	7.76	8.91	9.88	10.90	11.23	12.04	13.35
9580	0.29	1.55	2.90	4.05	5.18	6.01	6.95	8.10	8.94	9.84	10.12	10.75	11.90

STORM 156 - DEC 21-24, 1964
SIERRA NEVADA CENTER
39 38'N 120 59'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.05	5.50	8.76	11.43	13.50	15.72	17.91	20.41	22.38	23.25	23.90	24.92	26.17
10	1.05	5.50	8.76	11.43	13.50	15.72	17.91	20.41	22.38	23.25	23.90	24.77	26.17
50	1.03	5.39	8.59	11.21	13.24	15.42	17.57	20.03	21.96	22.82	23.46	24.14	25.69
100	0.98	5.14	8.22	10.71	12.84	14.89	17.09	19.57	21.47	22.32	22.94	23.69	25.15
200	0.89	4.67	7.49	9.78	12.56	14.52	16.21	18.76	20.62	21.49	22.05	23.20	24.65
500	0.79	4.00	6.54	9.57	12.16	14.07	15.53	17.76	19.64	20.61	21.25	22.55	23.99
1000	0.69	3.56	6.21	9.05	11.50	13.31	14.85	16.99	18.84	19.83	20.21	21.56	22.91
2000	0.59	3.21	5.76	8.27	10.36	12.04	14.07	16.14	17.90	19.04	19.61	20.27	21.73
5000	0.44	2.51	4.68	6.68	8.29	9.69	11.62	13.48	15.02	16.10	16.62	17.09	18.39
9903	0.35	1.86	3.63	5.17	6.48	7.48	8.63	10.13	11.28	12.16	12.56	13.03	14.07

STORM 156 - DEC 21-24, 1964
ELK VALLEY REGION, NORTHWESTERN CALIFORNIA REGION
41 52'N 123 40'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
2	2.05	5.35	7.62	10.02	14.05	15.83	17.10	20.33	21.11	22.56	23.23	25.04	26.28
10	2.05	5.35	7.62	10.02	14.05	15.83	17.10	20.33	21.11	22.56	23.23	25.04	26.28
50	1.93	5.21	7.39	9.81	13.83	15.44	16.64	19.93	20.78	22.03	22.64	24.37	25.60
100	1.72	5.11	7.23	9.65	13.67	15.24	16.31	19.64	20.55	21.75	22.26	23.87	25.16
200	1.59	4.90	6.96	9.33	13.25	14.74	15.74	19.05	19.94	21.09	21.56	23.05	24.36
500	1.27	4.28	6.27	8.50	12.11	13.39	14.48	17.56	18.36	19.37	19.80	20.94	22.37
1000	0.97	3.63	5.64	7.86	11.04	12.14	13.42	16.12	16.90	17.83	18.25	19.11	20.57
1923	0.72	2.98	5.02	7.25	9.83	10.81	12.26	14.51	15.30	16.15	16.57	17.27	18.69

STORM 156 - DEC 21-24, 1964
LAYTONVILLE REGION, NORTHWESTERN CALIFORNIA REGION
39 41'N 123 35'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.44	6.11	9.74	14.26	17.32	19.39	21.65	25.42	27.14	28.04	28.41	28.85	30.32
10	1.35	5.70	8.64	13.08	16.23	18.53	20.74	24.21	26.13	27.13	27.42	27.90	30.29
50	1.22	5.17	8.15	11.83	14.99	17.53	20.10	22.94	25.05	26.05	26.24	27.06	29.22
100	1.13	4.78	8.05	11.33	14.46	17.11	19.66	22.45	24.63	25.60	25.75	26.60	28.60
200	1.00	4.37	7.76	10.86	13.94	16.64	19.06	21.76	23.94	24.87	25.01	25.82	27.64
500	0.90	3.88	7.07	9.98	12.85	15.49	17.63	20.16	22.21	23.04	23.21	23.96	25.65
1000	0.72	3.43	6.38	9.06	11.65	13.91	15.83	18.10	19.94	20.65	20.81	21.46	22.96
2000	0.62	3.04	5.97	8.48	10.77	12.69	14.50	16.61	18.36	18.94	19.11	19.65	21.03
5000	0.54	2.70	5.29	7.55	9.47	11.03	12.58	14.37	15.84	16.40	16.55	16.98	18.18
5140	0.54	2.69	5.27	7.52	9.43	10.98	12.52	14.30	15.76	16.32	16.47	16.90	18.09

STORM 157 - DEC 20-24, 1964
ENTIRE STORM
44 14'N 115 29'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
1	0.93	3.20	3.43	3.68	4.89	5.32	6.37	7.53	7.87	8.13	8.26	8.40	8.87
10	0.93	3.20	3.43	3.68	4.89	5.32	6.37	7.53	7.87	8.13	8.26	8.40	8.87
50	0.90	3.10	3.34	3.65	4.89	5.32	6.37	7.53	7.87	8.13	8.26	8.40	8.87
100	0.86	2.99	3.24	3.56	4.84	5.27	6.29	7.43	7.76	8.01	8.14	8.28	8.74
200	0.83	2.87	3.14	3.49	4.75	5.17	6.16	7.25	7.57	7.81	7.93	8.07	8.52
500	0.75	2.63	2.94	3.38	4.61	5.02	5.91	6.89	7.18	7.40	7.52	7.65	8.05
1000	0.63	2.22	2.62	3.26	4.46	4.85	5.65	6.54	6.81	7.01	7.13	7.27	7.65
2000	0.50	1.80	2.33	3.13	4.27	4.62	5.33	6.14	6.39	6.57	6.70	6.85	7.23
5000	0.38	1.42	2.05	2.86	3.87	4.16	4.69	5.34	5.56	5.70	5.84	5.99	6.35
10000	0.31	1.21	1.84	2.42	3.34	3.62	4.01	4.51	4.80	4.95	5.11	5.21	5.55
20000	0.23	0.95	1.52	1.90	2.67	2.96	3.25	3.63	3.96	4.17	4.36	4.44	4.75
50000	0.14	0.58	0.99	1.29	1.75	2.14	2.37	2.59	2.79	3.05	3.21	3.35	3.54
59661	0.13	0.51	0.89	1.19	1.60	1.99	2.20	2.40	2.58	2.80	2.95	3.10	3.28

AREA (SQ. MI.)	DURATION (HR) 78	84	90	96
1	9.60	9.88	10.16	10.20
10	9.60	9.88	10.16	10.20
50	9.60	9.88	10.16	10.20
100	9.46	9.73	10.01	10.04
200	9.21	9.48	9.74	9.78
500	8.67	8.91	9.15	9.18
1000	8.22	8.44	8.66	8.70
2000	7.79	8.00	8.19	8.23
5000	6.83	7.00	7.15	7.19
10000	5.96	6.09	6.19	6.25
20000	5.10	5.21	5.30	5.40
50000	3.80	3.90	3.97	4.05
59661	3.51	3.60	3.68	3.75

STORM 165 - JAN 14-17, 1974
ENTIRE STORM
40 20'N 124 06'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.27	4.30	7.19	9.18	10.71	11.27	12.48	13.90	14.98	17.01	17.75	18.97	19.17
10	1.27	4.21	7.19	9.11	10.63	11.20	12.38	13.80	14.95	16.89	17.62	18.83	19.02
50	1.19	3.89	6.88	8.62	10.08	11.08	12.23	13.56	14.66	16.05	16.75	17.84	18.02
100	1.11	3.74	6.53	8.18	9.63	10.86	12.00	13.23	14.28	15.28	16.37	16.94	17.09
200	0.94	3.46	5.58	7.81	9.35	10.33	11.57	12.65	13.64	14.79	15.72	16.21	16.27
500	0.70	3.06	5.15	7.27	8.90	9.57	10.63	12.00	12.91	14.12	14.92	15.42	15.48
1000	0.57	2.61	4.95	6.98	8.49	9.09	9.72	11.42	12.22	13.63	14.36	14.88	14.95
2000	0.48	2.34	4.48	6.32	7.70	8.25	8.88	10.43	11.18	12.63	13.31	13.74	13.79
5000	0.43	1.96	3.77	5.44	6.68	7.21	7.90	9.17	9.87	11.11	11.84	12.15	12.20
10000	0.38	1.66	3.25	4.72	5.85	6.31	6.95	8.09	8.71	9.91	10.57	10.82	10.87
20000	0.33	1.47	2.52	3.74	4.79	5.47	6.24	7.24	7.65	8.77	9.34	9.57	9.67
50000	0.25	1.22	2.03	2.81	3.70	4.56	5.46	6.22	6.58	7.46	7.96	8.21	8.35
81179	0.22	1.09	1.82	2.56	3.31	4.04	4.82	5.46	5.93	6.69	7.17	7.40	7.57

STORM 165 - JAN 14-17, 1974
GIBSON HWY MTCE STATION REGION, NORTHWESTERN CALIFORNIA CENTER
41 08'N 122 16'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.13	3.85	5.99	8.88	10.52	11.20	12.33	13.79	14.95	15.67	17.10	17.20	17.20
10	1.13	3.85	5.90	8.65	10.27	11.20	12.33	13.79	14.95	15.67	17.10	17.20	17.20
50	1.00	3.38	5.65	8.25	9.75	11.08	12.23	13.56	14.66	15.38	16.70	16.79	16.79
100	0.92	3.20	5.55	8.14	9.63	10.86	12.00	13.23	14.28	15.01	16.23	16.32	16.32
200	0.79	3.09	5.32	7.81	9.27	10.33	11.57	12.65	13.64	14.49	15.54	15.64	15.64
500	0.65	2.68	4.85	7.09	8.42	9.32	10.63	11.61	12.49	13.43	14.33	14.44	14.44
1000	0.57	2.36	4.41	6.43	7.63	8.52	9.60	10.66	11.47	12.25	13.20	13.40	13.42
2000	0.46	2.08	4.01	5.82	6.96	7.70	8.65	9.74	10.40	11.15	12.07	12.32	12.36
2272	0.44	2.03	3.93	5.70	6.81	7.52	8.49	9.56	10.19	10.94	11.84	12.09	12.13

STORM 165 - JAN 14-17, 1974
OLYMPIC PENINSULA CENTER
47 47'N 123 41'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
6	0.95	4.30	6.10	6.84	8.91	9.52	10.09	11.35	13.34	15.98	16.82	17.12	17.12
10	0.95	4.21	5.99	6.78	8.86	9.49	10.09	11.35	13.24	15.75	16.75	17.02	17.02
50	0.95	3.89	5.59	6.56	8.66	9.39	10.09	11.35	12.86	14.90	16.52	16.67	16.68
100	0.94	3.74	5.40	6.44	8.54	9.31	10.05	11.31	12.67	14.52	16.37	16.48	16.49
200	0.82	3.46	5.10	6.10	8.09	8.89	9.64	10.86	12.22	13.96	15.72	15.95	15.98
500	0.68	3.06	4.56	5.47	7.28	8.06	8.80	9.91	11.17	12.69	14.27	14.57	14.62
1000	0.57	2.61	3.97	4.77	6.39	7.13	7.82	8.81	9.96	11.27	12.68	13.03	13.08
2000	0.48	2.23	3.40	4.09	5.50	6.15	6.78	7.62	8.61	9.71	10.90	11.23	11.28
4596	0.37	1.73	2.63	3.11	4.20	4.74	5.25	5.86	6.62	7.44	8.27	8.55	8.61

STORM 165 - JAN 14-17, 1974
SOUTH WASHINGTON CASCADES CENTER
46 11'N 121 31'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
4	0.80	2.97	5.35	7.33	8.11	8.46	9.68	10.18	10.68	11.46	11.91	12.13	12.13
10	0.78	2.92	5.25	7.20	7.96	8.31	9.50	10.00	10.49	11.25	11.70	11.91	11.91
50	0.73	2.70	4.87	6.67	7.40	7.77	8.93	9.47	9.92	10.71	11.18	11.43	11.43
100	0.67	2.52	4.55	6.23	6.94	7.37	8.51	9.13	9.55	10.40	10.92	11.20	11.21
200	0.62	2.35	4.24	5.80	6.49	6.97	8.09	8.79	9.18	10.09	10.65	10.98	10.98
500	0.56	2.11	3.82	5.23	5.89	6.43	7.54	8.34	8.68	9.67	10.30	10.69	10.69
1000	0.51	2.01	3.64	4.90	5.58	6.10	7.11	7.90	8.33	9.25	9.86	10.22	10.29
2000	0.44	1.88	3.41	4.52	5.21	5.67	6.59	7.27	7.79	8.60	9.16	9.46	9.60
4920	0.32	1.54	2.81	3.71	4.29	4.74	5.45	5.93	6.48	7.11	7.56	7.85	8.00

STORM 165 - JAN 14-17, 1974
NORTHWESTERN CALIFORNIA CENTER
40 20'N 124 06'W

AREA (SQ. MI) / DURATION (HR)

AREA (SQ. MI)	1	6	12	18	24	30	36	42	48	54	60	66	72
1	1.27	3.85	7.19	9.18	10.71	11.27	12.48	13.90	14.98	17.01	17.75	18.97	19.17
10	1.27	3.85	7.19	9.11	10.63	11.21	12.38	13.81	14.95	16.89	17.62	18.83	19.02
50	1.19	3.65	6.88	8.62	10.08	11.08	12.23	13.56	14.66	16.05	16.75	17.84	18.02
100	1.11	3.47	6.53	8.18	9.63	10.86	12.00	13.23	14.28	15.28	16.23	16.94	17.09
200	0.94	3.09	5.58	7.81	9.35	10.33	11.57	12.65	13.64	14.79	15.69	16.21	16.27
500	0.70	2.68	5.15	7.27	8.90	9.57	10.63	12.00	12.91	14.12	14.92	15.42	15.48
1000	0.57	2.56	4.95	6.98	8.49	9.09	9.72	11.42	12.22	13.63	14.36	14.88	14.95
2000	0.47	2.34	4.48	6.32	7.70	8.25	8.88	10.43	11.18	12.63	13.31	13.74	13.79
5000	0.37	1.96	3.77	5.44	6.68	7.21	7.90	9.17	9.87	11.11	11.84	12.15	12.20
10000	0.32	1.65	3.25	4.72	5.85	6.31	6.95	8.09	8.71	9.91	10.57	10.82	10.87
18947	0.29	1.31	2.56	3.81	4.86	5.52	6.28	7.29	7.70	8.84	9.41	9.64	9.73

STORM 165 - JAN 14-17, 1974
CENTRAL OREGON CENTER
44 56'N 123 38'W

AREA (SQ. MI) / DURATION (HR)

AREA (SQ. MI)	1	6	12	18	24	30	36	42	48	54	60	66	72
5	0.82	3.20	5.57	6.93	8.80	10.21	11.28	12.57	13.59	14.71	15.52	16.17	16.23
10	0.80	3.20	5.57	6.93	8.80	10.21	11.28	12.57	13.59	14.71	15.52	16.17	16.23
50	0.78	2.74	4.86	6.45	7.88	9.26	10.95	12.30	13.02	14.42	15.22	15.86	15.92
100	0.75	2.65	4.54	6.22	7.49	8.78	10.57	11.88	12.57	13.91	14.69	15.30	15.37
200	0.67	2.53	4.20	5.76	7.03	8.24	9.81	11.02	11.75	12.88	13.70	14.48	14.57
500	0.56	2.36	3.87	5.08	6.37	7.48	8.61	10.19	10.93	11.70	12.77	13.54	13.65
1000	0.52	2.26	3.72	4.92	6.04	7.01	8.20	9.65	10.30	11.03	11.99	12.67	12.75
2000	0.48	2.11	3.54	4.65	5.68	6.51	7.70	8.94	9.53	10.25	11.04	11.65	11.73
5000	0.43	1.79	3.12	4.23	5.03	5.78	6.74	7.71	8.18	8.88	9.53	10.02	10.12
7714	0.40	1.72	3.01	4.05	4.82	5.51	6.44	7.32	7.75	8.47	9.06	9.50	9.60

STORM 165 - JAN 14-17, 1974
NORTH CASCADES CENTER
48 19'N 121 05'W

AREA (SQ. MI) / DURATION (HR)

AREA (SQ. MI)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	0.86	3.01	4.86	5.87	7.48	9.33	11.40	11.92	12.70	13.76	14.37	14.98	15.32
10	0.71	2.99	4.83	5.75	7.45	8.95	10.24	11.52	12.70	13.76	14.37	14.98	15.32
50	0.61	2.68	4.56	5.59	7.08	8.71	10.09	11.52	12.70	13.76	14.37	14.98	15.32
100	0.59	2.53	4.33	5.43	7.08	8.71	10.09	11.52	12.70	13.76	14.37	14.98	15.32
200	0.55	2.35	4.04	5.23	6.81	8.42	9.87	11.23	12.45	13.52	14.16	14.82	15.14
500	0.47	2.09	3.65	4.97	6.45	7.75	9.33	10.45	11.75	12.77	13.49	14.23	14.50
1000	0.42	1.88	3.32	4.67	6.09	7.24	8.83	9.84	11.08	12.04	12.72	13.44	13.69
2000	0.37	1.63	2.90	4.10	5.32	6.42	7.84	8.66	9.68	10.60	11.17	11.85	12.07
5000	0.26	1.24	2.20	3.20	4.04	5.02	6.10	6.67	7.31	8.04	8.44	8.97	9.17
5875	0.25	1.17	2.09	3.04	3.79	4.71	5.74	6.27	6.87	7.54	7.92	8.41	8.61

STORM 165 - JAN 14-17, 1974
UPPER MATTOLE REGION, NORTHWESTERN CALIFORNIA CENTER
40 20'N 124 06'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
6	0.89	3.38	6.44	9.18	10.71	11.27	12.48	13.90	14.98	17.01	17.75	18.97	19.17
10	0.88	3.35	6.39	9.11	10.63	11.18	12.38	13.80	14.87	16.89	17.62	18.83	19.02
50	0.79	3.16	6.06	8.62	10.08	10.61	11.69	13.09	14.12	16.05	16.75	17.84	18.02
100	0.71	2.98	5.75	8.18	9.56	10.30	11.04	12.85	13.92	15.28	16.02	16.94	17.09
200	0.63	2.79	5.41	7.67	9.35	10.07	10.60	12.61	13.64	14.79	15.69	16.21	16.27
500	0.56	2.66	5.15	7.27	8.90	9.57	10.13	12.00	12.91	14.12	14.92	15.42	15.48
1000	0.52	2.56	4.95	6.98	8.49	9.09	9.72	11.42	12.22	13.63	14.36	14.88	14.95
2000	0.47	2.34	4.48	6.32	7.70	8.25	8.88	10.43	11.18	12.63	13.31	13.74	13.79
2895	0.44	2.14	4.12	5.83	7.12	7.62	8.25	9.67	10.37	11.81	12.45	12.82	12.87

STORM 168 - JAN 13-16, 1974
ENTIRE STORM
47 29'N 115 44'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
3	0.44	1.53	2.84	3.43	4.42	4.91	5.42	5.84	6.43	6.92	7.45	7.95	8.24
10	0.43	1.52	2.82	3.43	4.42	4.91	5.42	5.84	6.43	6.92	7.45	7.95	8.24
50	0.41	1.43	2.65	3.43	4.42	4.91	5.42	5.84	6.43	6.92	7.45	7.95	8.24
100	0.40	1.39	2.57	3.43	4.42	4.91	5.42	5.84	6.43	6.92	7.45	7.95	8.24
200	0.38	1.33	2.47	3.36	4.31	4.79	5.27	5.71	6.28	6.75	7.27	7.76	8.03
500	0.35	1.24	2.30	3.13	3.98	4.39	4.81	5.31	5.83	6.25	6.69	7.14	7.39
1000	0.32	1.13	2.12	2.79	3.51	3.87	4.22	4.77	5.25	5.61	5.97	6.38	6.63
2000	0.28	1.02	1.91	2.52	3.11	3.41	3.78	4.31	4.74	5.05	5.39	5.78	6.01
5000	0.22	0.86	1.65	2.26	2.70	2.91	3.37	3.84	4.20	4.44	4.80	5.20	5.38
10000	0.18	0.74	1.44	2.05	2.38	2.54	3.05	3.47	3.77	3.95	4.33	4.71	4.85
20000	0.15	0.62	1.21	1.74	2.01	2.15	2.62	2.95	3.21	3.35	3.66	3.96	4.08
42267	0.11	0.46	0.90	1.28	1.49	1.61	1.91	2.16	2.33	2.45	2.69	2.88	2.97

STORM 175 - DEC 24-26, 1980
ENTIRE STORM
44 55'N 123 44'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48
1	0.97	2.93	4.99	7.07	9.22	10.84	11.27	11.27	11.27
10	0.97	2.93	4.99	7.07	9.22	10.84	11.27	11.27	11.27
50	0.95	2.88	4.89	6.94	9.05	10.66	11.12	11.12	11.12
100	0.87	2.76	4.59	6.56	8.53	10.11	10.62	10.63	10.63
200	0.80	2.62	4.11	5.90	7.63	9.09	9.65	9.67	9.67
500	0.70	2.24	3.22	4.66	5.96	7.17	7.80	7.82	7.82
1000	0.58	2.06	2.77	3.99	5.08	6.16	6.84	6.87	6.87
2000	0.47	1.76	2.46	3.57	4.56	5.64	6.29	6.32	6.32
5000	0.36	1.36	2.00	2.95	3.78	4.78	5.38	5.41	5.41
10000	0.29	1.11	1.67	2.52	3.16	4.04	4.55	4.60	4.60
20000	0.23	0.90	1.43	2.19	2.68	3.48	3.95	4.03	4.03
24865	0.21	0.83	1.35	2.08	2.53	3.30	3.77	3.85	3.86

STORM 175 - DEC 24-26, 1980
COASTAL OREGON CENTER
44 55'N 123 44'W

AREA (SQ.MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
15	0.97	2.93	4.99	7.07	9.22	10.84	11.27	11.27	11.27
50	0.95	2.88	4.89	6.94	9.05	10.66	11.12	11.12	11.12
100	0.87	2.76	4.59	6.56	8.53	10.11	10.62	10.63	10.63
200	0.80	2.62	4.11	5.90	7.63	9.09	9.65	9.67	9.67
500	0.70	2.27	3.22	4.66	5.96	7.17	7.80	7.82	7.82
1000	0.58	2.06	2.77	3.99	5.08	6.18	6.84	6.87	6.87
2000	0.47	1.76	2.46	3.57	4.56	5.64	6.29	6.32	6.32
5000	0.36	1.36	2.00	2.95	3.78	4.78	5.38	5.41	5.41
6325	0.34	1.26	1.84	2.74	3.47	4.41	4.95	4.98	4.98

STORM 175 - DEC 24-26, 1980
CASCADES CENTER
45 50'N 122 05'W

AREA (SQ.MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
11	0.47	2.00	3.26	4.28	5.38	6.52	7.98	8.05	8.05
50	0.47	2.00	3.06	4.19	5.15	6.38	7.71	7.78	7.78
100	0.46	1.97	2.97	4.16	5.05	6.31	7.59	7.66	7.66
200	0.46	1.85	2.89	4.12	4.95	6.25	7.46	7.54	7.54
500	0.42	1.69	2.70	3.80	4.58	5.76	6.90	6.96	6.96
1000	0.39	1.56	2.44	3.50	4.20	5.43	6.32	6.39	6.39
2000	0.33	1.37	2.15	3.11	3.74	4.92	5.57	5.63	5.63
5000	0.27	1.17	1.75	2.60	3.23	4.22	4.65	4.69	4.69
7160	0.25	1.10	1.60	2.40	3.03	3.96	4.31	4.34	4.34

STORM 179 (176+178) - NOV 30-DEC 2, 1975
ENTIRE STORM
47 37'N 123 44'W

AREA (SQ.MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
2	1.13	3.58	6.17	8.06	9.35	10.88	13.17	14.27	15.29	15.58	17.69	18.90	19.28
10	1.01	3.58	5.73	8.06	9.35	10.86	13.17	14.27	15.29	15.58	17.69	18.90	19.28
50	0.82	3.44	5.56	7.90	9.16	10.64	12.90	13.98	14.98	15.27	17.33	18.52	18.89
100	0.78	3.31	5.50	7.71	8.93	10.38	12.58	13.64	14.61	14.89	16.91	18.07	18.43
200	0.76	3.17	5.41	7.44	8.62	10.02	12.16	13.18	14.11	14.39	16.33	17.45	17.80
500	0.64	2.71	4.85	6.78	7.89	9.36	11.27	12.19	13.08	13.37	15.16	16.16	16.56
1000	0.53	2.32	4.21	5.78	6.84	8.40	9.92	10.71	11.54	11.88	13.41	14.27	14.78
2000	0.47	2.12	3.63	4.78	5.98	7.51	8.76	9.58	10.60	11.15	11.91	13.18	14.05
5000	0.40	1.79	3.07	3.94	5.11	6.53	7.68	8.46	9.30	9.77	10.55	11.55	12.25
10000	0.34	1.58	2.65	3.27	4.03	4.95	5.69	6.53	7.36	7.76	8.52	9.44	10.10
20000	0.27	1.35	2.26	2.75	3.41	4.18	4.84	5.49	6.15	6.59	7.20	8.00	8.55
31912	0.22	1.18	2.00	2.46	3.05	3.81	4.48	5.19	5.77	6.25	6.76	7.46	7.93

STORM 179 (176+178) - NOV 30-DEC 2, 1975
CASCADES CENTER (STORM 176 PORTION)
47 59'N 121 20'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
2	1.13	3.15	6.17	7.08	8.83	10.88	12.56	13.39	13.94	14.33	15.73	16.39	17.11
10	1.01	2.98	5.72	6.71	8.64	10.62	12.27	13.08	13.62	14.09	15.36	16.01	17.07
50	0.82	2.82	5.04	6.35	8.23	10.22	11.77	12.54	13.14	13.60	14.68	15.60	16.70
100	0.78	2.74	4.76	6.13	7.92	9.94	11.43	12.18	12.86	13.31	14.28	15.33	16.43
200	0.70	2.59	4.47	5.83	7.36	9.37	10.80	11.60	12.48	12.93	13.78	14.87	15.92
500	0.57	2.46	4.15	5.47	6.91	8.63	9.97	10.84	11.97	12.42	13.12	14.42	15.38
1000	0.51	2.29	3.84	5.13	6.45	8.08	9.36	10.23	11.43	11.88	12.53	13.89	14.78
2000	0.47	2.12	3.51	4.70	5.98	7.54	8.79	9.61	10.60	11.15	11.91	13.18	14.05
5000	0.40	1.79	2.95	3.94	5.11	6.53	7.68	8.46	9.30	9.77	10.55	11.55	12.25
10000	0.31	1.28	2.15	3.08	3.98	4.94	5.68	6.53	7.36	7.76	8.52	9.44	10.10
13720	0.27	1.06	1.85	2.72	3.50	4.30	4.80	5.67	6.47	6.87	7.56	8.44	9.05

STORM 179 (176+178) - NOV 30-DEC 2, 1975
COASTAL CENTER (STORM 178 PORTION)
47 37'N 123 44'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
5	0.85	3.58	5.73	8.06	9.35	10.86	13.17	14.27	15.29	15.58	17.69	18.90	19.28
10	0.85	3.58	5.73	8.06	9.35	10.86	13.17	14.27	15.29	15.58	17.69	18.90	19.28
50	0.81	3.44	5.58	7.90	9.16	10.64	12.90	13.98	14.98	15.27	17.33	18.52	18.89
100	0.78	3.31	5.50	7.71	8.93	10.38	12.58	13.64	14.61	14.89	16.91	18.07	18.43
200	0.76	3.17	5.41	7.44	8.62	10.02	12.16	13.18	14.11	14.39	16.33	17.45	17.80
500	0.64	2.71	4.85	6.78	7.89	9.36	11.27	12.19	13.08	13.37	15.16	16.16	16.56
1000	0.53	2.31	4.21	5.78	6.84	8.40	9.92	10.71	11.54	11.84	13.41	14.27	14.73
2000	0.46	2.02	3.63	4.78	5.91	7.11	8.18	8.95	9.61	9.96	11.27	12.02	12.49
5000	0.39	1.76	3.07	3.92	4.68	5.32	6.07	7.07	7.96	8.59	9.50	10.30	10.96
10000	0.34	1.58	2.65	3.27	3.99	4.73	5.34	6.04	6.70	7.16	7.83	8.44	8.92
12997	0.32	1.52	2.49	3.02	3.74	4.52	5.17	5.77	6.32	6.69	7.25	7.77	8.17

SYNOPTIC DESCRIPTIONS

The following synoptic descriptions cover storms from the sample in Table 2.1 considered most significant to this study, and are included to give insight to the types of conditions supporting these major events. None of the storm analyses attempted here have created cross sections or involved isentropic analysis that would show in temporal detail the relative moisture flows. Such analysis of vertical sounding data is more time consuming than could be justified for this study. Similarly, synoptic discussions in other hydrometeorological reports have included maps that depict the position of pressure centers and major fronts. Such maps have not been included in this study because of the time needed to draft them and it was believed that their importance could be replaced by the word descriptions that follow.

STORM: 12
DATE: 11/18 - 19/09
LOCATION: Western Montana near Snowshoe
DURATION: 48 hours

SYNOPTIC DESCRIPTION: The setting for this storm showed deep continental polar air settled over the intermountain region with a well established high pressure cell centered over southwestern Utah. A series of short waves originating well off the coast, moved eastward toward the surface ridge. These waves formed into occluded fronts with long south to southwest fetches into the region.

The first wave moved onshore and over the storm region on the 17th. This brought generally light to moderate precipitation to the area. The occlusion dissipated with eastward movement and the southwesterly flow was reestablished by the high pressure cell prior to the onset of the next wave.

Vertical motions due to the orographic lifting became important as the maritime Pacific air moved across land. Additional lifting was supplied by the colder polar air mass. On the 19th, the moisture trajectory became more westerly as the next front passes through the area and brings an end to the supply of moisture into this storm.

Precipitation began on the morning of the 17th and the precipitation moved eastward across Idaho and into Montana by about 1600 LST of the same day. The heaviest reported rainfall was recorded on Snowshoe, Montana, at 7.05 inches. The most intense rainfall fell with the second impulse, which apparently included slightly stronger vertical motions.

STORM: 38
DATE: 11/18 - 22/21
LOCATION: North central Oregon near the Cascade Mountains
DURATION: 72 hours

SYNOPTIC DESCRIPTION: Continental polar air drifted southward over Washington and into Oregon as an approaching low pressure system moved across the Gulf of Alaska and a ridge built up off the California coast near 35N, 135W. The polar air became stalled in central Washington and the major push went southeastward. The offshore ridge shifted gradually to the east, while taking on a more northeast-southwest orientation. The main energy of the Pacific disturbance continued its easterly movement and became well defined by the 18th.

Minor shortwaves traveled east along the Washington/Oregon border bringing some precipitation to the interior. The southwesterly flow moving into the coast was forced over the stationary polar front, in addition to the orographic lifting. These strong flows continued until the 21st when a cold front associated with the low pressure system finally moved onshore. Heaviest precipitation appeared to be associated with the strong southwesterly flows that had their origin in tropical latitudes. Temperatures in the southwesterly air were in the 50's, while to the north of the front they were below freezing.

Winds increased with the approach of the low pressure system. Precipitation appeared to have been focused by the stationary front and the lifting provided by the Cascades. Rainfall was heaviest in northwestern Oregon and southwestern Washington, with the highest observed amount at Wind River, Washington, where over 15 inches was reported. The precipitation began as light rain early on the 18th, becoming heavy that evening, and continuing early on the 20th. Thereafter, moderate rainfall prevailed through the 21st becoming light again on the 22nd.

STORM: 40
DATE: 12/9 - 12/21
LOCATION: North Central Cascades
DURATION: 72 hours

SYNOPTIC DESCRIPTION: A broad area of high pressure extended over the Great Basin and southwestward into the Pacific off of California. Substantial flows of moist air on the backside of this ridge followed a trajectory from near Hawaii to the coastal area of Washington on the 9th. Over the Aleutians, a low pressure system moved to the north-northeast, with a trailing cold front.

The cold front became occluded as it pushed onshore through British Columbia, with surface winds increasing to over 30 kt along the Washington coast. The low pressure system intensified very quickly as it moved toward the northeast on the 10th. A second front moved onshore on the 11th causing a momentary shift in winds to the west before returning to the southwest ahead of the next system.

Winds increased to 40 kt along the coast on the 12th as a result of the occluded front and the intensified pressure gradient. This appeared to have produced the heaviest precipitation in the core region. The rainfall came to an end on the 13th.

The cause of heavy rainfall was attributed to the strong southwesterly flow encountering the coastal and Cascade Mountains during the 10th and 11th, supported by a strong pressure gradient. The rainfall occurred in two surges; the first and lesser surge was from the afternoon of the 9th to the morning of the 10th, while the heavier surge fell between late on the 10th through the morning of the 12th. The heaviest rainfall was reported at Silverton, Washington, where 15.38 inches occurred.

STORM: 80
DATE: 1/20 - 25/35
LOCATION: Olympic Mountains
DURATION: 144 hours

SYNOPTIC DESCRIPTION: The conditions leading to this storm developed on the 16th and 17th when a quick moving storm passed through western Washington to the Great Basin by the 19th. This passage was followed by ridge development and the merging of an eastern Pacific High, with a strong continental polar anticyclone centered in the Yukon Territory. Over the next few days, this joint high pressure system intensified to create an effective block to subsequent storms moving to the east. As the next storm wave approached the coast from the Gulf of Alaska, the combined pressure ridge served to intensify the gradient of SSW flows toward the Washington Coast and the Olympic Mountains.

Extremely cold temperatures were observed over Washington and Oregon, with below zero readings reported in eastern parts of the two states. Beginning on the 21st, the strong southwesterly flows brought warming temperatures and moisture to the coast where the mountains forced lifting that was intensified by convergence in the numerous valleys. These conditions led to a period of continuous rains for several days. Rain rates of 12 inches a day were noted on the 21st and 22nd, indicative of release of conditional instability. It was estimated that gradient level flows in excess of 60 kt impacted the mountainous slopes to produce vertical velocities ten times the normal 0.3 fps for general storms.

Quinault Ranger Station on the southwest corner of the Olympics measured over 37 inches of rainfall during the 144 hours of this storm.

Precipitation began as snow on the 21st, but changed to rain early on the 22nd in western Washington. Unusually deep snows were observed east of the Cascade ridge, with 52 inches measured at Winthrop. Dew point temperatures rose to the 40's and low 50's by the 23rd, matching the air temperatures near the coast. As an indication of the subtropical air flowing into the region, Mount Baker Lodge recorded a temperature of 70°F on the 25th, within 2° of the all-time high for January in the state.

STORM: 88
DATE: 12/26 - 30/37
LOCATION: Coastal Mountains of Washington, Oregon
DURATION: 96 hours

SYNOPTIC DESCRIPTION: This storm brought moist flows into the coastal mountains of Oregon and Washington, with numerous rainfall centers in excess of 10 inches. The largest observed amount occurred near Valsetz, Oregon, where some 25 inches fell on the southwest facing slopes. The mountains in this region rise to levels between 3500 and 4000 feet.

The primary storm of the 28th to 30th followed a series of quick moving, low pressure centers that passed through western Washington to the east. On the 26th, a low moved into the Gulf of Alaska and rapidly deepened during the next 30 hours. This resulted in both a slowing of movement and an intensification of the onshore gradient that increased the winds to the coastal mountains. A quasi-stationary front developed along the Washington/Oregon border. Several short waves passed along this surface that provided rain impulses during the storm. Movement of the frontal surface southward and then back northward may have contributed to the maximum rains occurring in Oregon.

By the 30th, the front had been displaced eastward and the rains ceased along the coastal mountains except for a few showers. Most of the mass curves for this storm show rain occurring in two bursts separated by about 30 hours. It is also apparent from these curves that little convective activity was associated with this event.

From the Northern Hemisphere Daily Weather Maps, dew points appear to be in the low 40's, with air temperatures ranging between 55° and 61° F. Temperatures at this level are indicative of trajectories from subtropical latitudes at this time of year.

STORM: 106
DATE: 6/26 - 27/44
LOCATION: Eastern end of Snake River Valley
DURATION: 24 hours

SYNOPTIC DESCRIPTION: This is a somewhat perplexing storm in that from study of the synoptic conditions, there is little to distinguish events occurring during this period from those that occur in a number of other storms. Nevertheless, this storm produced rains that exceeded the level of 1-percent chance rains for June. A rather weak stationary front existed across eastern Washington, and into Montana on the 25th. During the next 24 hours, pressure fell in central Idaho and formed a small low pressure system that intensified and moved into the Dakotas by the 27th. It was within this development that rains lasting to 14 hours occurred in southern Idaho and western Montana. The maximum observed rains approached 4 inches in eastern Idaho. Some of this rain appeared to be convective early in the period, followed by continuous light rain. Other parts of the storm had mass curves without convective traces evident. It would appear from this limited examination that the convective cells were imbedded in the more general-type event. Also, it would appear that in other parts of the storm, orographic lifting may be responsible for the majority of rainfall.

It was difficult to determine the source of moisture for this storm in that there was no evidence of any gradient flow from the Pacific during or preceding the rain period. Likewise, there was no strong push of moisture from the Gulf of Mexico shown on these maps and it must be concluded that the moisture arrived at levels above the surface. It was also possible that some of the moisture was residual, although the period preceding the storm shows little evidence of past rains. Speculation was that the moisture was the result of a surge or surges that have pushed northward through the Great Basin from subtropical sources west of the Continental Divide. This track for intermountainous moisture has been determined for a number of local storm events in the region and was difficult to detect without extensive analysis (moisture cross sections, etc.).

This storm would not be significant when compared with the other storms in this sample were it not for the location of the largest rainfall. There have been few storms reported that resulted in rains of this magnitude in least orographic regions.

STORM: 126
DATE: 10/25 - 30/50
LOCATION: Western Washington, Oregon and northern California
DURATION: 72 hours

SYNOPTIC DESCRIPTION: Numerous rainfall records were set during this 5-day period in northern California and southern Oregon. Gasquet Ranger Station measured 26.1 inches, Eureka, California, had 13.04 inches and 34 of 37 stations in California set new October records.

The critical storm period for this storm occurred between mid-day of the 26th and mid-day of the 29th, with the bulk of the rain falling from two primary rain sequences. The first impulse of 6 to 12-hour duration occurred early in the period, while the second impulse occurred near the end of the sequence. This 5-day event was discussed at length by Smith (Monthly Weather Review, October 1950), who described it as one of the strongest storms to hit the coastal region from mid-California north to British Columbia. Extensive damage as well as loss of life occurred from the high winds and flooding throughout the area. Aside from the record rains, this storm period brought a number of record low pressure readings to the three coastal states. Tatoosh Island, Washington, reported an all-time October minimum pressure of 971.6 mb, while Eureka, California, reported a record low of 986.8 mb.

Smith reported that the sequence of storms was preceded by a mass of very cold air that moved out of Siberia on the 22nd. By the 24th, this cold air had passed over Tatoosh Island and formed a large pool of cold air at low levels that was overlain by relatively warm air that intensified the frontal boundary and strengthened the low pressure systems. The first low pressure center entered the coast near the center of Oregon, associated with a cold front that draped through northern California. This storm moved rapidly eastward, while a second low moved into position in the Gulf of Alaska. Late on the 27th, this second storm moved southeastward and entered the coast near the U.S./Canadian border.

A brief comment can be made concerning dew points. Only a limited amount of data existed to indicate that dew points were near normal (upper 30's to low 50's) during the period, having come from moist air believed to originate around 30° N latitude. Some of the mass curves suggested that convective bursts were included in the otherwise general type rains. Widespread convection was not evident, however.

STORM: 143
DATE: 10/1 - 2/57
LOCATION: North-central Oregon
DURATION: 24 hours

SYNOPTIC DESCRIPTION: This storm resulted in the largest rainfalls (3.49 inches) near Hermiston, Oregon, a least orographic region, and like storm 106, it resulted from conditions that were not well organized. That is, a small thermal low moved into southeastern Oregon on the 1st and widespread convective activity was noticed throughout Oregon and eastern Washington. By October 2nd, a weak cold front had passed through western Washington and trailed into Oregon near Portland. Rain was reported ahead of this front and appeared to be associated with the upper level trough. It was concluded that the rains were the result of local convergence that released instability in the resident air mass over the Great Basin.

It was not clear where the moisture came from, as the surface maps gave no indication of moist tongues from the south. Locally, Pendleton, Oregon, had a persisting dew point of 51° F, which when adjusted to 1000 mb gives 59° F, not unusual for this date. At Hermiston, the rain occurred over a period of about 12 hours, while at most of the other stations, the rain appeared as bursts of 4 to 8-hour lengths, indicative of the convective nature of this storm.

STORM: 149
DATE: 11/21 - 24/61
LOCATION: Southwestern Oregon
DURATION: 72 hours

SYNOPTIC DESCRIPTION: A deep low pressure center, located over southwestern Alaska on the 20th, moved toward the southeastern Alaskan coast by the 21st. Central pressure was less than 970 mb, and an occluded front trailed southward along the coast to the southern end of Vancouver Island. Here, a warm front branched off and into the Oregon coast that initiated a three-day period of rainfall over western Washington and Oregon. By the 22nd, the warm front was replaced by a cold front that rotated clockwise to align itself east-west across the coast between the 22nd and 23rd. The tight gradient through this sequence pulled strong southwesterly winds onshore into the coastal mountains. Heavy snow was reported throughout the mountains, causing power outages and some road closings. The heaviest rains were noted along the coast with Brookings, Oregon, recording over 10 inches. Precipitation ended the morning of the 24th, as a wave passed along the front, pulling it southward into California.

It is possible that some of the moisture entering this storm was pulled northward from the remnants of tropical storm Dot; however, available synoptic analyses were insufficiently clear off the coast to support this claim. Moisture from such a source would more than account for the high rains observed.

Most of the precipitation fell in the western portions of the two states. It was believed that the combination of strong convergent flows and orographic lifting concentrated most of the heavy rains against the major mountain slopes. Unseasonably cold temperatures preceded the passage of the warm front into the region. This undoubtedly accounted for the heavy snows reported in the mountains.

STORM: 155
DATE: 6/7 - 9/64
LOCATION: Northern Montana Rockies
DURATION: 48 hours

SYNOPTIC DESCRIPTION: This storm was known as the Gibson Dam storm because of the extreme runoff that caused runoff to overtop the dam, substantially. The synoptic analysis for this event has been described in both HMR 43 and HMR 55A, and will not be repeated here. However, recent review of some features in the analysis have brought about a few additional comments that are worth noting, as follows.

In the initial discussion of this event by Dightman (Bonner and Stermitz, 1967), easterly winds of 30 kt were claimed responsible for vertical velocities needed to support the observed rains. Using the best upper air station relative to this event (Great Falls) to get weighted averages for various layers below 20,000 feet, does not support winds of 30 kt. At best, winds around 15 kt are possible from about 60°. In that Great Falls probably is representative of winds to the southern part of the storm, it is still possible that stronger winds, of the magnitude suggested by Dightman, occurred to the north.

In reviewing the moisture trajectory to this storm, it is noted that there were multiple inflows possible, depending upon the time considered. HMR 55A states that the major moisture flows into the storm came from a reference location in western Kansas (Grand Island). Radar reports, on the other hand, appear to support inflow to the storm site through northeast Colorado. This source region seems to dominate during the 15 hours between 00 and 15 GMT on the 8th. Prior to this period, a Pacific source region appeared to be effective, while after 15 GMT, the best moisture flows came from the vicinity of Regina in Canada. Certainly, a three-source moisture inflow has to be considered unusual, but considering the significance of this storm, it is difficult to determine the importance of this feature to the observed rains.

Furthermore, examination of the 200-mb temperatures and lower level temperature changes suggest that stratospheric warming occurred during the course of this event. The dynamics of the atmosphere were therefore more representative of winter, although the surface flows provided summer-like moisture to the region. This combination may represent the optimum conditions for maximizing orographic effects and support the particular significance of the Gibson Dam storm.

STORM: 165
DATE: 1/13 - 17/74
LOCATION Coastal Washington and Oregon
DURATION: 72 hours

SYNOPTIC DESCRIPTION: A strong high pressure system prevailed over the Gulf of Alaska, representing a block to storms entering the west coast on the 10th. Very cold arctic air from the north and northeast persisted across the coastal states. Severe negative temperature departures were observed over portions of Washington and Oregon, with below zero temperatures reported throughout the region east of the Cascades. The blocking high began to regress westward by the 11th, allowing a surge of warm air to enter the coast at the southern end of the region. Both temperatures and dew point temperatures rose significantly during a 24-hour period beginning the 12th. Rapid cyclogenesis developed in the Gulf in place of the high pressure system, and a number of short waves moved around the trough at the time of the increasing temperature and moisture flows. Early snowfall changed to rain that intensified with time as the gradient increased and as the orographic influences took over.

Coastal winds were reported at 60 mph along the Washington coast, increasing to 75-100 mph along the Oregon coast. Winds of such magnitude cause considerable damage but also support the strong orographic effects noted in the precipitation pattern for this storm. Beginning on the 16th, a second short wave began to push through the region, bringing an end to this period of heavy rains.

Mount Shasta, California, set an all-time 24-hour rainfall of 6.97 inches during this storm, and Sexton Summit, Oregon, set 12-, 24- and 72-hour records of 3.39, 5.98 and 11.52 inches, respectively. Over 9 inches fell on a large portion of western Oregon, while a few stations had maxima of nearly 13 inches.

STORM: 179
DATE: 11/29 - 12/4/75
LOCATION: Western Washington and Oregon
DURATION: 72 hours

SYNOPTIC DESCRIPTION: Storm 179 is a combination of storms 176 and 178, effectively joining a northern and southern portion to what was considered two large precipitation patterns. What was storm 177, covering a subportion of storm 176 for the Olympic Mountains, is included, as well.

The temporal and spatial distribution of the precipitation associated with this storm was controlled by several factors. Initially, the development and subsequent movement of a classic, well-defined warm front and its associated dynamics were the primary mechanisms responsible for widespread heavy precipitation throughout the region. After the 30th, precipitation was caused by a combination of a strong surface to 700-mb onshore flow, orographic effects, and the relative closeness of a quasi-stationary surface frontal system acting as a focusing mechanism.

A series of short waves moved through the west coastal zone prior to the 28th, leading to the deepening of an upper level pressure trough along the western states. A strong jet stream edged southward during the period, with core winds up to 100 kt. The jet stream was aligned north-northwest to south-southeast and this became more westerly after the 30th.

The deep trough along the coast moved to the east beginning the 30th, creating a more zonal pattern aloft during the first few days of December. The jet stream remained over northern Washington through the storm period, finally moving into Canada at the end of the rains. The movement of the jet stream coincided with the surface movement of the polar front. North of the front were unseasonably cold temperatures, while to the south was relatively warm maritime air. Warming at all levels took place through the period of intense precipitation during this storm. Although the origin of the warm air was difficult to trace, the temperatures entering the coast were 50-60° F. Precipitation was concentrated along the frontal slopes and was further focused by the various orographic features encountered. Prior to the warm front, most all the precipitation fell as snow. After the front moved in, mostly rain was reported throughout the region. Rain was not constant through the period, but appears to have come in two primary bursts. The first burst occurred early in the period and the second, particularly in the northern stations, fell on the 2nd to 3rd. Weak high pressure built back into the region after the 4th ending this storm.

STORM: SEYMOUR FALLS
DATE: 1/12 - 17/1961
LOCATION: Southwestern British Columbia, Canada
DURATION: 126 hours

SYNOPTIC DESCRIPTION: Depth-area-duration analysis for this storm was officially made by Environment Canada, who determined that the Seymour Falls rain amounted to some 20.87 inches, beginning late on the 12th and tailing off late on the 15th, essentially making this a 72-hour storm. Bear Creek, on the lower end of Vancouver Island, received 15.93 inches during the same period, but was not part of the isohyetal pattern analyzed for the Seymour Falls center.

This storm is interesting in that conditions favorable for a sequence of frontal waves to pass into southern British Columbia at 24-hour intervals, produced the significant rains observed at Seymour Falls. At 00 GMT, on each of the 13th, 14th and 15th, a front moves through the Pacific coastal region. The last of the sequence moved slowest and produced the most intense rains. The fronts appeared to be spun off from an intense low pressure system that was anchored in the Gulf of Alaska. Strong pressure gradients were set up through Washington and British Columbia that caused convergence of flows north of a ridge of high pressure that extended in north-central California. The trajectory of moist warm air, feeding into the storm area ahead of the fronts, can be traced back along the north side of the ridge to latitudes of 30° F or lower.

The upper air pattern supported low latitude flows, as a trough occurred off the coast, with ridging along the western states. Strong warm air advection occurred ahead of the trough. This pattern appears to remain fixed throughout the period of this storm. The inflowing moist air encountered strong uplifting when crossing the coast and striking the coastal mountains of northwest Washington and southern British Columbia.

APPENDIX 3

STORM SEPARATION METHOD

The Storm Separation Method (SSM) was developed in Hydrometeorological Report (HMR) 55A as method to obtain the convergence component of PMP and a corresponding orographic factor, and provided a means to obtain total PMP. The discussion in Chapter 6 essentially describes the modifications made to the SSM for the present study.

As a convenience to the reader of this report, and for those who may not have access to HMR 55A, the entire Chapter 7 of HMR 55A that describes the SSM has been reprinted in this appendix. The SSM is a complex analytical process that has been tested by numerous meteorologists during its original development. The results indicated that an acceptable level of comparability between results was possible when analysts had considerable experience in storm analysis.

7. STORM SEPARATION METHOD

7.1 Introduction

In order to establish PMP in the CD-103 region, it was considered necessary to find a property of observed major storm precipitation events that is only minimally effected by terrain so transposition of observed precipitation amounts would not be limited to places where the terrain characteristics are the same as those at the place where the storm occurred. The name given to this idealized property is "free atmospheric forced precipitation" (FAFP) which has been called "convergence only" precipitation in publications such as HMR No. 49 (Hansen et al. 1977). For a more complete definition of FAFP, see the Glossary of Terms in section 7.2. It is emphasized that FAFP is an idealized property of precipitation since no experiment has yet been devised to identify in nature which raindrops were formed by orographic forcing and which by atmospheric forcing. This chapter explains how FAFP may be estimated for specific storms. Background information is provided on the development of the storm separation method (SSM).

7.2 Glossary of Terms

Terms frequently used in the SSM are listed alphabetically.

A_o: See P_a. It is the term for the effectiveness of orographic forcing used in module 3.

AI: The analysis interval, in inches, for the isohyets drawn for a storm.

B_i: See PCT2. It is the term representing the "triggering effects" of orography. It is used in module 2. B_i is a number between 0 and 1.0 representing the degree of FAFP implied by the relative positioning of the 1st through i-th isohyetal maxima with those terrain features (steepest slopes, prominences, converging upslope valleys) generally thought to induce or "stimulate" precipitation. A high positive correlation between terrain features and isohyetal maxima yields a low value for B_i. For each isohyetal maximum there is just one B-type correlation and, thus, if the area covered by a given maximum is extensive enough so that more than one area category is contained within its limits, the B correlations are determined using all isohyets comprising a particular maximum. For the larger-area/shorter-duration categories, the B_i correlation may need to be made in widely separated, noncontiguous areas.

When available, the chart of maximum depth-area-duration curves from the Part II Summary of the storm analysis*, along with its associated documentation, is the primary source for determining how many centers (n) and which isohyetal maxima were used to determine the average depth for the area being considered.

BFAC: 0.95 (RCAT). It represents an upper limit for FAFP in modules 2 and 5. See also the definition for PX.

DADRF: The depth-area-duration reduction factor is the ratio of two average depths of precipitation.

DADRF = RCAT/MXVATS

DADFX: DADFX = (HIFX)(DADRF). It is used in module 2 to represent the largest amount of nonorographic precipitation caused by the same atmospheric mechanism that produced MXVATS.

F_i: See PCT2. It is the term for the "upsloping effects" of orography and it is used in module 2. It is a number between 0 and 1.0, which represents the degree of atmospheric forcing implied by the orientation of the applicable upwind segments of the isohyets with elevation contours (high positive correlation of these parameters means a low value for F_i) for the 1st through i-th maxima. For an isohyetal maximum there is just one F-type correlation, and if the area covered by a given maximum is extensive enough so that more than one area category is contained within its limits, the F correlations are the same for each of the area catagories. F-type correlations are determined using all isohyets comprising a particular maximum. As with B-type correlations, maximum depth-area-duration curves from the Part II of the storm report should be used to determine which precipitation centers are involved in the isohyetal maximum.

*A depth-area-duration storm analysis is separated into two parts. The first part develops a preliminary isohyetal map and mass curves of rainfall for all stations in the storm area. The second part includes a final isohyetal map, computation of the average depth of rainfall over all isohyetal areas and determination of the maximum average depth for all area sizes up to the total storm area. The complete procedure used for making depth-area-duration analysis is described in "Manual for Depth-Area-Duration Analysis of Storm Precipitation" (World Meteorological Organization 1986).

FAFP: Free Atmospheric Forced Precipitation is the precipitation not caused by orographic forcing; i.e., it is precipitation caused by the dynamic, thermodynamic, and microphysical processes of the atmosphere. It is all the precipitation from a storm occurring in an area where terrain influence or forcing is negligible, termed a nonorographic area. In areas classified as orographic, it is that part of the total precipitation which remains when amounts attributable to orographic forcing have been removed. Factors involved in the production of FAFP are: convergence at middle and low tropospheric levels and often, divergence at high levels; buoyancy arising from heating and instability; forcing from mesoscale systems, i.e., pseudo fronts, squall lines, bubble highs, etc.; storm structure, especially at the thunderstorm scale involving the interaction of precipitation unloading with the storm sustaining updraft; and lastly, condensation efficiency involving the role of hydroscopic nuclei and the heights of the condensation and freezing levels.

HIFX: The largest isohyetal value in the nonorographic part of the storm. The same atmospheric forces (storm mechanism) must be the cause of precipitation over the areas covered by the isohyet used to determine HIFX and MXVATS.

I_m: That part of RCAT attributed solely to atmospheric processes and having the dimension of depth. Since it is postulated that FAFP cannot be directly observed in an orographic area, some finite portion of it was caused by forcing other than free atmospheric. The FAFP component of the total depth must always be derived by making one or more assumptions about how the precipitation was caused. The subscript "m" identifies the single assumption or set of assumptions used to derive the amount designated by I. For example, a subscript of 2 will refer to the assumptions used in module 2. The key assumptions of all the modules are detailed in section 7.3.1. Refer to the schematic for each module in figures 7.3 to 7.6 for the specific formulation for each I_m.

LOFACA: LOFACA is the lowest isohyetal value at which it first becomes clear to the analyst that the topography is influencing the distribution of precipitation depths. Confirmation of this influence is assumed to occur when good correlation is observed between the LOFACA isohyet and one or more elevation contours in the orographic part of the storm.

How is LOFACA found? A schematic isohyetal pattern is shown by the solid lines in figure 7.1 to illustrate this procedure. Start at the storm center and follow the inflow wind direction out to the lowest valued isohyet in the analysis (no lower than 1 in.) located in the orographic part of the storm. If the storm pattern is oddly shaped, it may be necessary to use a direction slightly different from the exact inflow direction. Any direction within ± 22.5 degrees either side of the inflow direction which allows comparisons of the sort described above is acceptable. The vector CL in the schematic of figure 7.1 represents the path in this storm that is parallel to the inflow wind and directed at the lowest valued isohyet. Next, draw

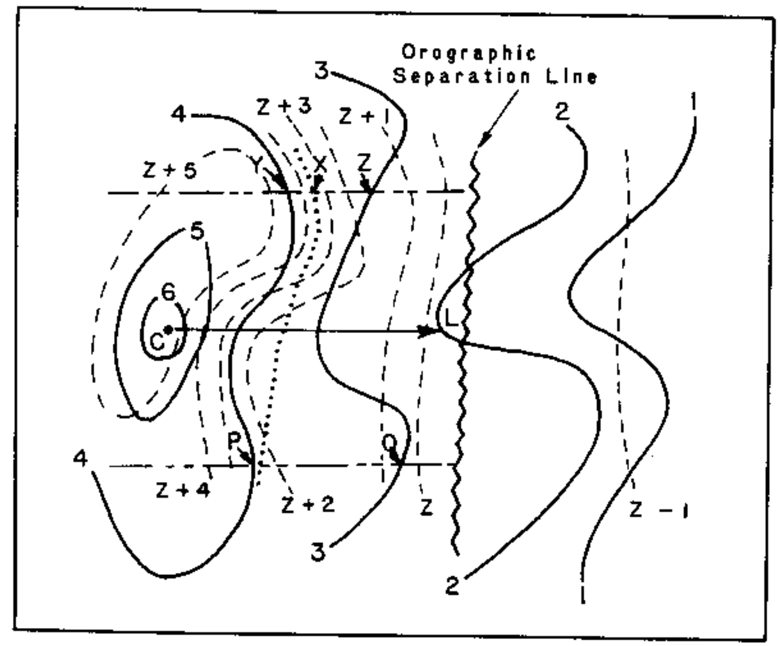

Figure 7.1.—Schematic illustrating determination of LOFACA.

two lines parallel to and either side of the vector CL. Each of the parallel lines will be drawn at a distance from CL of 1/2 the length of CL. These lines are the dash-dot lines in figure 7.1. These lines will be called "range lines." The range lines end at the orographic separation line (the saw-toothed line in figure 7.1) since only correlations in the orographic part of the storm are important in determining LOFACA.

The next step is to examine those isohyets which intersect the range lines down wind of the storm center of isohyetal maximum. Such segments are considered candidate isohyetal segments (CIS) and they are depicted by the segments of the isohyets PY and QZ in figure 7.1. The objective is to determine which CIS has a good correlation with topographic features indicated by the dashed lines. A good correlation is a CIS that parallels one of the smoothed elevation contours along one-half or more of its length. When no isohyet is found meeting the criterion, LOFACA is defined to be zero. As depicted in the schematic, the 4-in. CIS indicated by the solid line (from P to Y) shows a good correlation with the Z + 2 and Z + 3 contours, so the value of LOFACA is 4 in. If the 4-in. isohyet in figure 7.1 had been along the dotted line from P to X, there would have been a poor correlation and the value of LOFACA would have been zero for this storm.

The significance of LOFACA is that precipitation depths at and below this value are assumed to have been produced solely by atmospheric forces without any additional precipitation resulting from topographic effects; i.e., they represent the "minimum level" of FAFP for the storm. If more than one isohyetal center exists for the area size selected, the procedure is followed for each center. If the value of LOFACA is different for two or more of these centers, the lowest of the values is used as the one and only value of LOFACA for that storm and area size.

LOFAC: $\text{LOFAC} = \text{LOFACA} + \frac{\text{AI}}{2}\left(\text{PB}^{\frac{(\text{AI})}{2}} - 1\right).$

It is a refinement to LOFACA based on the concept that AI may prejudice the assigning of a minimum level of FAFP.

MXVATS: The average depth of precipitation for the total storm duration for the smallest area size analyzed, provided that it is not larger than 100 mi^2. It is obtained from the pertinent data sheet (P.D.S.) for the storm included in "Storm Rainfall" (Corps of Engineers 1945 -). It is used in several modules to calculate percentages of FAFP. If the area criterion cannot be met, the storm is not used in the study.

n: When used in module 2 it is the number of analyzed isohyetal maxima used to set the average depth of precipitation for a given area size.

OSL: Orographic Separation Line is a line which separates the CD-103 region into two distinct regions, where there are different orographic affects on the precipitation process. In one region, the nonorographic, it is assumed no more than a 5-percent change (in either increasing or decreasing the precipitation amount for any storm or series of storms) results from terrain effects. In contrast, the other region is one where the influence of terrain on the precipitation process is significant. An upper limit of 95 percent and a lower limit of no less than 5 percent is allowed. The line may exist anywhere from a few to 20 miles upwind (where the wind direction is that which is judged to prevail in typical record setting storms) of the point at which the terrain slope equals or exceeds 1,000 ft om 5 miles or less with respect to the inflowing wind direction (sec. 3.2).

P_a: P_a (and A_o) is a ratio in which the effectiveness of an actual storm in producing precipitation is compared with a conceptualized storm of "perfect" effectiveness. In such a conceptual model, features known by experience to be highly correlated with positive vertical motions, or an efficient storm structure, would be numerous and exist at an optimum (not always the largest or strongest) intensity level.

Thus,

$$P_a = \frac{\text{Effectiveness of Actual Atmospheric Mechanisms}}{100}$$

where the numerator is a number between 5 and 95

$$A_o = \frac{\text{Effectiveness of Actual Orographic Mechanisms}}{100}$$

where the numerator is a number between 0 and ±95.

It would have been desirable to express both P_a and A_o in physically meaningful units; however, this was not considered practical because the available meteorological data for most of the storms of concern are generally extremely limited. Hence, the present formulation is expressed in terms of subjective inferences about physical parameters known to be effective in the production of precipitation either in major storms in nonorographic regions or by considering the results of flow of saturated air against orographic barriers. This type of formulation is required, because of the limited availability of meteorological information for the storms, but is considered adequate for the purposes of this report. Mechanically, the effectiveness of the particular storm is derived by using the checklists in module 3.

PA: The ratio of the nonorographic area containing precipitation to the total storm precipitation area is given by PA. Its inverse is used when setting a realistic upper limit for I_2 and I_5 (see definition for PX on the following page). Areas in which the depth of precipitation is less than 1 in. are not used in forming the ratio. In contrast to PC, PA does not depend upon the area size being considered in the storm separation method.

PB: When the LOFACA isohyet does not extend from the orographic part into the nonorographic part of the storm, it is the ratio of the sum of the areas in the nonorographic part containing amounts equal to or greater than LOFACA (the numerator) to the total nonorographic area in which precipitation depths associated with the storm are 1 in. or more. When the LOFACA isohyet does extend into the nonorographic part of the storm, the numerator is increased by an amount representing the area bounded by the LOFACA isohyet and the OSL. It is used in module 2 in setting a value for LOFAC. Note: when LOFACA is zero, PB will be one and LOFAC will also equal zero.

PC: It is used in the formulations of PCT1, PCT2, and PCT3 to take into account the contribution of nonorographic precipitation to total FAFP (which includes FAFP contributions from orographic areas). It is expressed as a number between 0 and 0.95 The value of the upper limit is 0.95 because no storm in which more than 95 percent of the precipitation fell in nonorographic areas was considered. Thus, some storms from the list of important storms were not considered since they occurred in the nonorographic region.

If, for the area size being considered, part of the total volume of precipitation occurred in a nonorographic area, PC is the ratio of that partial volume to the total volume. If none of the total volume was nonorographic, PC = 0. The ratio of volumes is obtained by forming the ratio of the corresponding area sizes first, then multiplying that ratio by an estimate of the average depth in the nonorographic area, and finally dividing this result by the average depth for the total area, both of these depths occurring at maximum duration.

PX: is the smaller of either BFAC or DADFX multiplied by $(PA)^{-1}$ except when PA = 0, in which case PX = BFAC. Once selected, PX serves to define what is a realistic upper limit for I_2 and I_5.

PCT1: $PCT1 = PC + \frac{RNOVAL}{MXVATS}(0.95 - PC)$.

MXVATS is used only for the smallest area size on the P.D.S. (provided that it is not greater than 100 mi^2) because the average depth at larger area sizes is influenced by how isohyets were drawn.

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PCT2: $PCT2 = PC + \left(\frac{\sum_{i=1}^{n} (F_i + B_i)}{2n}\right)(0.95 - PC)$

It is a number between 0 and 0.95 where n is the number of isohyetal maxima in the orographic part of the storm applicable to the area/duration category being considered. Estimates of F- and B-type correlations are dependent upon the quality of the isohyetal analysis and upon proper identification of the precipitation centers involved in the area category under consideration. When there is no Part II storm study information available, the analyst must decide whether a reasonable estimate can be made for n. When there are just a few maxima, each at a different depth, a reasonable estimate is likely, whereas when there are numerous maxima all of which are for the same depth and which enclose about the same area, it is less likely that a reliable value for PCT2 can be calculated. When the latter is the case, the answer to question 13 in module 2 will be "no" and the analyst documents this situation in module 5 after completing modules 3 and 4.

PCT22: This is the ratio I_2/RCAT where I_2 is the total amount of RCAT that is PAFP. I_2 is defined by the relationship:

$I_2 = [LOFAC + (MXVATS - LOFAC)PCT2]DADRF$

Substitution of these terms into the definition for PCT22 leads to the relationship:

$PCT22 = PCT2 + \left(\frac{LOFAC}{MXVATS}\right)(1 - PCT2)$

PCT3: $PCT3 = PC + \left(\frac{P_a}{P_a + A_o}\right)(0.95 - PC)$

It is a dimensionless number usually between 0.05 and 0.95, representing the percent of the total depth of precipitation for a given area/duration category attributable to the atmospheric

processes alone. It is obtained not only by considering primarily meteorological information, but also by considering the following minimal list of additional information: a P.D.S. for the storm (DAD data) including the location of the storm center; a chart of smoothed contours of terrain elevation; and precipitation data sufficient to define where precipitation did or did not occur. More detailed precipitation information is used, when available.

The range of 0.05 to 0.95 is considered reasonable, because it is postulated that the orographic influence never completely vanishes, and when the orographic influence is predominant, precipitation would not continue without some contribution from atmospheric forcing mechanisms. Though not expected to occur, it is conceivable that PCT3 may exceed 0.95 if the estimated orographic forcing was downslope, actually decreasing the total possible precipitation. This matter is discussed further in the section dealing with module 3. The formulation for PCT3 is meant to apply only to major storms and definitely not to minor storms where negative terrain forcing on lee slopes might approach, or exceed, the magnitude of the atmospheric forcing.

RCAT: The average depth of precipitation for the selected category. The "CAT" indicates that the parameter R is a variable depending on category definition.

RNOVAL: Representative nonorographic value of precipitation. It is the highest observed amount in the nonorographic part of the storm. The value of RNOVAL is not adjusted to the elevation at which MXVATS is believed to have occurred. RNOVAL and MXVATS must result from the same atmospheric forces (storm mechanism).

7.3 Background

The SSM was developed in the present format because four distinct sets of precipitation information were available for record-setting storms in the CD-103 region. These were:

1. Reported total storm precipitation, used in module 1.

2. Isohyet and depth-area-duration analyses of total storm precipitation, including Part I and Part II Summaries, used in module 2.

3. Meteorological data and analyses therefrom, used in module 3.

4. Topographic charts, used in all modules.

Since the quantity and quality of the information in the first three of these sets would vary from storm to storm, it was concluded that a method which relied on just one of the first three sets (along with topographic charts) might be quite useless for certain storms. Alternatively, one could have a SSM which always combined information from the first three sets. This choice was rejected since, for most of the storms, one or more of the sets might contain no useful information and bogus data would have to be used. Clearly, the SSM depends on the validity of the input information.

300

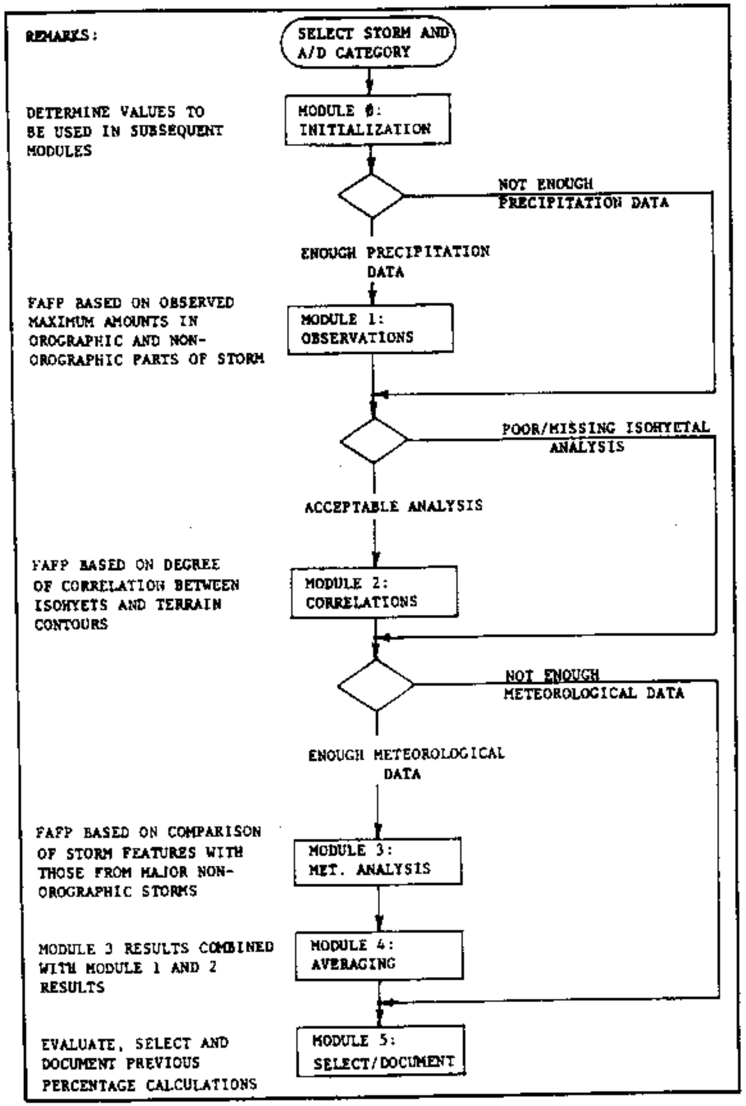

Figure 7.2.—Main flowchart for SSM.

Four sets of information are used in the SSM to produce up to five estimates c FAFP for area categories up to 5,000 mi^2 and durations up to 72 hr for storm with major rainfall centers in areas classified as "orographic." The mechanic of the procedure used to arrive at one numerical value of FAFP for any relevan area/duration (A/D) category for any qualifying storm are accomplished b completing the tasks symbolically represented in a MAIN FLOWCHART for the SS (fig. 7.2) along with its associated SSM MODULE FLOWCHARTS (fig. 7.3 to 7.7) wit references to the following items:

1. Glossary of Terms (sec. 7.2).
2. Concepts for use of the modules (sec. 7.3.1).
3. Specific questions to be answered in the MAIN FLOWCHART and the MODUL FLOWCHARTS.

7.3.1 Basic Concepts

The validity of the techniques in the SSM depends on the validity of th concepts upon which they are based. Evaluation of these concepts is crucial i the application of the procedure. A relative evaluation of the validity of th concepts underlying the individual modules will govern which of the five possibl values will be used for FAFP for a given A/D category. The evaluation i formalized in module 5 (column E) of the SSM based on the analysts evaluation o the various concepts. Several concepts are basic to acceptance of the procedur as a whole (all modules) while others relate to the evaluation of individua modules.

7.3.1.1 Overall Method. The total depth of precipitation for a given A/ category is composed of precipitation that results from atmospheric forces an from the added effect of orography. The method assumes that the effect o orography may either contribute to or take away from the amount of precipitatio that is produced by the atmosphere. When the orographic effect is positiv (expressed as a percentage contribution to total precipitation), it may not b less than 5 percent. If it is also assumed that the terrain surrounding th location where a given storm of record occurred had been transparent; i.e., ha no effect on the atmospheric forces acting there, the resulting total precipitation would be the same as the free air forced component of precipitation fo the actual storm.

It is assumed that the FAFP never completely disappears in storms of record, and the total volume may contain contributions over both the orographic an nonorographic areas. The further assumption is made that, when no other information is available at the shorter durations, inferences made fro precipitation depths valid at maximum storm duration for a given area are equall valid for the same area at shorter durations down to and including the minimu duration category.

7.3.1.2 Module 1. There are three components that underlie the use o precipitation observations in the estimation of the contribution of th atmosphere to the precipitation amounts in storms. These are:

1. If free atmospheric forcing in the nonorographic part of the storm ha been smaller that it was, the value of the maximum depth o precipitation would have been proportionally less.

2. The FAFP in the orographic region of the storm is approximated by the maximum precipitation depths in the nonorographic region, as long as the same atmospheric forces are involved at each location.

3. Estimates of the FAFP based on assumptions 1 and 2 are better for small rather than intermediate or large area sizes.

7.3.1.3 Module 2. This module uses an isohyetal analysis of the precipitation data to evaluate the free air forced component of precipitation. Inherent in the use of this module is the existence of an isohyetal analysis based on adequate precipitation information and prepared without undue reliance on normal annual precipitation or other rainfall indices which may induce a spurious correlation between the precipitation amounts and topography. In addition, there are five other concepts underlying this module. These are:

1. One or more than one level of LOFACA may exist in the orographic part of a storm. When more than one storm center is contained in a given area category, the lowest level of LOFACA found is used for that area size.

2. LOFACA exists when there is a good correlation between some isohyet and elevation contours.

3. Upsloping and triggering (F- and B-type correlations) are of equal significance in determining the percentage of precipitation above LOFACA which is terrain forced.

4. For an orographic storm (centered in th orographic portion of the region), the larger the nonorographic portion becomes (in relation to the total storm area), the more likely that the observed largest rainfall amount in the nonorographic portion (as represented by DADFX) is the "true" upper limit to FAFP in the orographic part of the storm.

5. Estimates of FAFP using the above assumptions are better at intermediate and large rather than small area sizes.

7.3.1.4 Module 3. This module makes use of the meteorological analysis and the evaluation of the interaction of dynamic mechanisms of the atmosphere with terrain to estimate the FAFP. There are seven basic concepts underlying the use of this module. These are:

1. Estimates of FAFP made using the techniques of this module may be of marginal reliability if the storms considered are those producing moderate or lesser precipitation amounts.

2. A variety of storms exist, each one of which has an optimum configuration for producing extreme precipitation.

3. The more closely the atmospheric forcing mechanisms for a given storm approach the ideal effectiveness for that type of storm, the larger the effectiveness value (P_a) for that storm becomes.

4. The FAFP is directly proportional to the effectiveness of atmospheric forcing mechanisms and inversely proportional to the effectiveness of orographic forcing mechanisms.

5. If the effectiveness of the orographic forcing mechanisms is of opposit sign to the effectiveness of the atmospheric forcing mechanisms and o equal or larger magnitude, little or no precipitation should occur.

6. The FAFP of storms of record is arbitrarily limited to no more thar 100 percent of the maximum precipitation depth for the area/duratior category under consideration.

7. Estimates of FAFP using the above assumptions are better at large rather than at intermediate or small area sizes.

7.3.1.5 Module 4. A basic assumption underlying the use of module 4 is that better results can be obtained by combining information; i.e., averaging the percentages obtained from the isohyetal analysis with the meteorological analysis and those obtained from analysis of the precipitation observations with the meteorological analysis. Better estimates are produced by averaging when there is little difference in the expressed preference for any one of the techniques or sources of information and, also, when the calculated percentage of FAFP from each of the modules exhibits wide differences.

Little is to be gained from use of the averaging technique over estimates produced by one of the individual analyses of modules 1, 2, or 3 when:

1. There are large differences in the expressed preference for the techniques of one module.

2. The sources of information for one of the individual modules is definitely superior.

3. The calculated percentages among the modules are in close agreement.

7.4 Methodology

The SSM was developed in a modular framework. This permits the user to consider only those factors for which information is available for an individual storm. A MAIN FLOWCHART of the SSM is shown in figure 7.2.

The MAIN FLOWCHART gives the user an overview of the SSM. Modules 1, 2, and 3 are designed to use the first three information sets mentioned in section 7.3 as indicated by the remarks column at the left side of the flowchart. A decision must be made initially for any storm and category as to which modules can be appropriately used, module 1, 2, or 3. The decision is based on a minimum level of acceptability of the information required by the module in question. The decisions are formalized for each of these three modules in module 0. The heart of the SSM procedure is module 5 where documentation is made of the SSM process, thereby permitting traceability of results. Though module 5 can be reached on the flowchart only after passing through each of the other modules, it is recommended that the steps in each module be documented in the record sheet of module 5 as the analyst proceeds. Transposition and moisture maximization of the index value of precipitation follows the completion of the SSM and will be discussed in chapter 8.